

REPORT UPON THE INQUIRY RESPECTING FOOD-FISHES AND THE FISHING-GROUNDS.

BY RICHARD RATHBUN, *Assistant in charge.*

NORTH PACIFIC OCEAN AND BERING SEA.

The principal investigations conducted under this division during the past year have related to the fur seal in the North Pacific Ocean and Bering Sea, the oyster-grounds and other fishery matters along the Atlantic seacoast, and the requirements for fish-culture in the Rocky Mountain region and the Gulf States.

The steamer *Albatross* has been much more actively employed than during any previous year, if the amount of work accomplished be measured by the time spent at sea and the total distance sailed, but only a very short period was given specially to that class of fishery inquiries with which this ship has hitherto been chiefly occupied. Early in the fall a brief reconnaissance was made of the Strait of Juan de Fuca, which served to make known its principal resources, and to point out the difficulties which must be encountered in prosecuting extensive fisheries in that deep arm of the sea. During the balance of the year, however, fishing and dredging trials were only incidental features of the work. From September 18, 1891, until March 12, 1892, the *Albatross* was engaged, under the direction of the Secretary of the Navy, in running two lines of deep-sea soundings between the coast of California and the Hawaiian Islands, with the object of determining if a practicable route exists across that part of the Pacific Ocean for the laying of a telegraphic cable, a task which was successfully accomplished, notwithstanding the unfavorable season chosen for that purpose and the inclement weather met with during most of the cruise.

Aside from this purely hydrographic survey and the short stay made in the Strait of Juan de Fuca, the operations of the *Albatross* have related exclusively to the fur-seal inquiries in connection with the preparation of the Bering Sea case for the proposed tribunal of arbitration at Paris. During the summer of 1891, this ship acted simply as a transport for the Bering Sea commissioners, Dr. Mendenhall and Dr. Merriam, conveying them to and from the Pribilof Islands, but on March 15, 1892, she entered directly into the investigations which were then begun to settle some of the main points in controversy respecting the habits of the fur seals and the effects of pelagic sealing.

The habits of these animals during the period of their residence on the Pribilof Islands have been studied with considerable care, and upon the knowledge thus obtained has been based a judicious system of regulations, not entirely perfect, perhaps, but which, if properly carried out, could not fail to insure the perpetuation of the herd. Whatever abuses may have been practiced on those islands, they could have produced little or no effect upon the main or breeding parts of the rookeries, as the supply of skins was drawn entirely from the so-called hauling-grounds, which are occupied solely by the bachelors or non-breeding males. The marked decrease on the breeding-grounds, beginning only a few years ago, was evidently due to some influence from without, and its cause was not difficult to discover. An interference of this character with the seal fishery had never been anticipated by the Government of the United States, and no steps had been taken, therefore, to investigate the conditions associated with the movements of this highly-prized species during its long wanderings in the open sea. Whether the possession of such information would have helped to avert the injury which is now being done or not, it would at least have greatly strengthened this Government in its efforts to obtain a just recognition of its claims, and it is therefore greatly to be deplored that the work was left until its urgency was demonstrated by force of circumstances.

In view of the material interests involved, a somewhat heated controversy could not be avoided between the two countries whose subjects claimed protection in what they regarded, on each side, as their respective rights. On the one side there was a long-established industry, whose continuity need not be broken except by unwise administration, while on the other there was a young and enterprising fishery, gaining strength every season, and bound eventually not only to sap its own resources, but to destroy the rookeries as well. This was practically the status of the fur-seal question when arbitration was suggested and agreed upon, a *modus vivendi* prohibiting pelagic sealing in Bering Sea being arranged for at the same time. It was now too late to begin a systematic and thorough study of the entire subject, which, under suitable conditions, would have been productive of much more satisfactory and convincing results, and provision was made for investigating only the more salient features of the problem, on which there was a wide diversity of opinion between the British and American representatives.

Three vessels were assigned to this duty, the Fish Commission steamer *Albatross* and the revenue steamers *Corwin* and *Bear*. The cruising-ground of the *Albatross*, up to the close of the fiscal year, was mainly off the southern side of the Alaska Peninsula and along the Aleutian chain, from Prince William Sound, in the east, to Attu Island and to the Commander Islands, off the Siberian coast. The representations made on the part of Great Britain that the eastern body of fur seals has other hauling-grounds than the Pribilof Islands were disproved, and the entire weight of the evidence obtained tends

to show that the American and Asiatic herds do not mingle, each being quite independent of the other.

Another important discovery was made by Mr. Charles H. Townsend, the naturalist of the steamer *Albatross*, who was sent to Guadeloupe Island, off the coast of Lower California, where the Alaskan fur seal was said to haul out regularly during the period of its southern distribution in the winter. Specimens obtained there and brought to Washington proved to belong not only to a different species than the northern form, but to represent as well a totally distinct genus. The investigations of the *Albatross* were still in progress at the end of the year.

Further assistance was rendered to the agent of the United States in preparing the Bering Sea case by the assistant in charge of this division, who was called upon to present a review of the principal ocean fisheries of the world, together with a compilation of all foreign laws for the protection of marine products and the regulation of the industries pertaining thereto. This work, which required several months for its completion, served to bring out many interesting features of legislation, some of the most conspicuous in respect to the disregard of the traditional 3-mile zone being afforded by the British colonies in the southern hemisphere. As an illustration may be noted the regulations of New Zealand, which, by provisions as stringent as those of the *modus vivendi* now in force in Bering Sea, seek to protect the fur seals, once so abundant in that region, over an area measuring 20° in latitude by 25° in longitude, the greatest width of water in that area, measured from the coast of the middle island of New Zealand, being 700 miles. On the western side of the island of Ceylon, moreover, along a strip of water frontage exceeding 20 miles in width, any vessel "anchoring or hovering and not proceeding to her proper destination" during certain months is subject to seizure and confiscation as a menace to the pearl fishing banks. These laws and many others of equal novelty which might be quoted are probably entirely justifiable, but if the right to enforce them is recognized in respect to one country, the exercise of such right may be justly claimed in all analogous cases.

The steamer *Fish Hawk* has spent a large part of the year in delineating the oyster-grounds in different parts of Chesapeake Bay, and in determining their condition by careful and detailed investigations. The work accomplished has proved of great practical value in bringing forcibly to the attention of the governments of Maryland and Virginia the necessity of affording greater protection to their oyster territory, and the advantages offered by those waters for greatly increasing the production of this mollusk. Virginia has already taken steps to profit by this information and will seek to encourage private oyster-culture as a means of utilizing large tracts of bottom which are well adapted to oyster growth, but yield no returns at the present time. In some countries of Europe, and notably in France, the cultivation of the oyster has been brought to a high state of perfection. While it is not expected that the methods there employed can be advantageously

introduced into this country, it was thought that a study of the subject could not fail to furnish many valuable suggestions which would be appreciated by American oyster-growers. Arrangements were accordingly made with Dr. Bashford Dean, of Columbia College, New York, who went to Europe in the summer of 1891 on private business, to undertake this work, which he has already completed with respect to France, Spain, and Portugal, and his report upon the methods practiced in the first-mentioned country has been received and published.

The physical inquiries respecting the waters off the southern New England coast, begun in 1889 by the schooner *Grampus* and conducted the next year by the same vessel in conjunction with the Coast Survey steamer *Blake*, were continued during the summer of 1891 by the *Grampus* alone. The work was carried on, as in previous years, under the direction of Prof. William Libbey, jr., of Princeton College. Just before the close of the fiscal year the schooner *Grampus* was detailed to commence upon a systematic investigation relative to the bottom fishes in the lower part of Chesapeake Bay and the adjacent waters of the ocean, which it was proposed to continue during a large part of the summer.

Although the attendance at the Woods Holl laboratory during the summer of 1891 was not as large as usual, much effective work was accomplished, and very important results were also obtained through the efforts of Mr. V. N. Edwards, who has been the resident collector at that place since 1871. The most noteworthy of his observations have been those respecting the breeding habits of the menhaden, which, it seems now to be quite definitely decided, spawns in the coastal waters instead of at sea, as was originally supposed.

The practical utility of the inland or fresh-water investigations, first systematically taken up in 1888, was well demonstrated during the past year, when this division was called upon to determine, under a special act of Congress, the advisability of establishing hatching-stations in the Rocky Mountain region of Montana and Wyoming and in the Gulf States. Although only a small amount of money was available for this purpose, yet entirely satisfactory results were accomplished, owing in large part to information acquired through previous inquiries conducted partly in the same region and partly in other waters having corresponding features. It is expected that in the course of not many years these researches will have covered the different parts of the United States so completely as to furnish the groundwork for a more thoroughly comprehensive system of fish-culture than it has been possible to establish hitherto. The conduct of the inland work has been mainly under the immediate direction of Prof. B. W. Evermann, the principal assistant in this division. His inquiries in Montana were supplemented by Prof. S. A. Forbes, director of the Illinois State Laboratory of Natural History. Investigations on a smaller scale were also carried on in the States of Kentucky, Tennessee, North Carolina, Indiana, Ohio, and New York.

The studies and experiments relative to the propagation of the Spanish mackerel in Chesapeake Bay begun in June, 1891, were completed later in the same summer, and although the number of eggs obtained and hatched was relatively small, sufficient information was secured to indicate the proper methods to pursue in case it should be deemed advisable to increase the abundance of this important food-fish by artificial means. The great falling off in the supply of this species which has taken place during recent years would seem to justify such action.

A case of river pollution brought to the attention of the Fish Commission has been thoroughly investigated, and although the results obtained were not entirely conclusive, advantage was taken of the opportunity to conduct a very interesting series of observations. The source of pollution is a wood-pulp paper mill situated on the banks of the Susquehanna River, the waste liquor from which finds its way directly into the stream. The harmful influence of the sulphurous acid thus discharged was practically demonstrated upon fishes held in confinement, but it yet remains to be decided whether the volume of water in the river at the site of the mill is sufficient to overcome the pernicious effects of the acid or not. In smaller streams there could be no question as to the harm produced from such a cause.

Studies upon the diseases of fishes, a subject which has been very generally neglected, notwithstanding its important relation to the welfare of fishes in general and to successful fish-culture in particular, have been carried on at intervals during the year by Dr. R. R. Gurley, who has been mainly occupied in bringing together the literature on the subject and in preparing a monograph on one of the most extensive groups of injurious parasites, the Myxosporidia. Several special cases of disease have also been made the subject of inquiry.

CRUISE WITH THE BERING SEA COMMISSIONERS.

At the beginning of the fiscal year the steamer *Albatross* was at San Francisco, Cal., prepared to start upon a trip of investigation to the Alaskan coast, where it was proposed to continue the survey of the fishing-banks in Bering Sea, begun the previous summer.

During the season of 1890 the work had been confined mainly to the extreme southeastern part of that sea, including Bristol Bay as far up as the mouth of the Nushagak River, but exceedingly important results had been obtained in the development of Baird and Slime banks, the former of very large size and both comparatively little known as regards either their hydrography or fishery resources. The narrow stretch of shallow water along the northern side of Unalaska Island was also explored at the same time, and several lines of deep-sea soundings served to define the approximate outer limits of the continental platform as far north as latitude $58^{\circ} 43' N.$, or about 168 miles northwesterly from St. Paul Island, of the Pribilof group.

It had been intended the present year to extend the surveys in a westerly and northerly direction as far as circumstances would permit, and judging from the success obtained in 1890 it was expected that additional fishing-grounds of great value would be discovered and marked out. Other and more urgent requirements of the public service, which arose at this time, however, made it necessary to abandon these plans, and to dispatch the *Albatross* on a special mission.

In connection with the controversy respecting pelagic sealing in the North Pacific Ocean and Bering Sea, between Great Britain and the United States, commissioners had been appointed by both Governments to investigate the conditions of seal life in those regions, and, no other suitable vessel being available, the *Albatross* was, by direction of the President, placed at the service of the two representatives on the part of the United States, Prof. T. C. Mendenhall and Dr. C. Hart Merriam. Instructions announcing this change of detail were telegraphed to the commander of the *Albatross* on July 9, and on the 16th of that month, both commissioners having arrived on board, the ship set sail directly for Unalaska, where she arrived on the 25th. The steamer *Danube*, conveying the British commissioners, Sir George Baden-Powell and Dr. George M. Dawson, reached Unalaska on the same day.

After coaling, the *Albatross* proceeded to St. George Island, the more southern of the two Seal Islands, remaining there a part of one day, and thence going to St. Paul Island on the afternoon of July 28. On the following day the commissioners took up their residence on shore, owing to the difficulty and, at times, uncertainty of making a landing from the ship. There are no protected harbors on either of the Pribilof Islands, and anchorages have to be changed with the shifting of the winds whenever the latter are strong, but, according to Lieut. Commander Tauner, an able steamer may lay safely at anchor long after communication with the shore has become impracticable. The officers of the *Albatross* did not participate directly in the seal investigation, but rendered such assistance as was requested of them by the Bering Sea commissioners. Visits were paid, however, to some of the rookeries and killing-grounds, and many incidental observations were recorded. On July 29 the ship was called upon by the Treasury agent at the islands to aid in capturing a schooner which had been detected in killing seals with rifles off Northeast Point rookery, but the poacher had been seized by the revenue-cutter *Corwin* before the *Albatross* arrived upon the spot.

On August 3 a fishing and dredging trip was made off the southern and western sides of St. Paul Island, the beam trawl being used at five stations, in depths of 20 to 51 fathoms. The bottom was found to consist of fine gray or black sand and shells, with scattered pebbles and traces of black mud in some places. A great variety of invertebrate life was obtained, but not many specimens of any group, except starfishes and sea-cucumbers, which were very abundant. Only a

small number of fishes were taken in the beam trawl, among them being young cod, pollock, and flounders, and nothing was secured by means of hand lines, although they were tried in several places. Later in the same day a series of hydrographic soundings was made off the western extremity of St. Paul Island. According to Lieut. Commander Tanner:

The natives report that cod and halibut frequent the waters about the Pribilof Islands during the winter and early spring, but the former disappear soon after the seals arrive and only a few of the latter remain during the summer. Neither of these species is ever taken in large numbers. It is a well-known fact that feeding seals go farther from the islands in search of food as the season advances, until in the latter part of July they reach the vicinity of the 100-fathom line south and west of the Pribilofs, from 50 to 100 miles and more from their rookeries.

A number of sea-lion skins, prepared for use as museum specimens, were procured on August 4, and two days later a fishing party, sent out in small boats, covered considerable ground, but returned with only three halibut and five small cod. The *Albatross* left the Pribilof Islands on August 10, bound south, and the following morning anchored off Bogoslof Volcano, on which the Bering Sea commissioners and several officers of the ship were landed for the purpose of making observations. The following interesting notes based upon this visit are from the report of Lieut. Commander Tanner:

We noted many changes since our visit the previous year. New Bogoslof was still active, smoke and steam escaping through numberless crevices throughout the whole mass from the water's edge to the summit. It was at least 100 feet lower, and was otherwise changed in outline; what had been the rocky pinnacle was now lying in huge masses strewn down the steep incline, even to the surface of the sea.

* * * * *

The old and new volcanoes are about a mile apart and were, a year ago, connected by a narrow isthmus but little above the level of the sea, composed of fine volcanic cinders. Now, however, there is an open passage through it several hundred feet in width near the new cone, the remainder of the spit extending from Old Bogoslof having been removed bodily to the westward with a broad sweep. A bar or middle ground was found a few hundred yards to the eastward of a line drawn between the cones. * * * The beaches, the banks above mentioned, and the isthmus formerly connecting the two cones are composed of fine cinders, ashes, etc., lighter than sand or gravel, and are, in consequence, washed back and forth with every heavy gale. * * * A sea-lion rookery referred to in former reports, near the base of Old Bogoslof, was occupied as usual. This colony is notable for the unusual size of some of the old bulls. They seemed quite tame, permitting several of the shore party to approach close to them before showing signs of fear; their location being remote from the usual routes in Bering Sea, they are seldom disturbed.

Unalaska was reached in the evening of August 11, and on the 13th the ship passed out into the North Pacific Ocean, through Unalga Pass, bound for the northern end of Vancouver Island. Thence the inland passage was taken to Tacoma, Wash., stops being made at Alert Bay, Departure Bay, and Port Townsend. At Alert Bay the salmon cannery and Indian village were visited, and a collection of the native hunting and fishing implements was made for the World's Columbian Exposition. The commissioners left the ship at Tacoma on August 22.

STRAIT OF JUAN DE FUCA.

As the season was too far advanced when the *Albatross* reached Tacoma from the special trip to Bering Sea to justify her returning north for the purpose of continuing the fishery investigations in the Alaskan region, instructions were issued to make a thorough study of the fishing-grounds in the Straits of Juan de Fuca and Puget Sound, where practically no work of this character had hitherto been undertaken. Scarcely more than a week elapsed, however, after starting upon this inquiry before it was interrupted, and very little was accomplished, therefore, beyond running a few lines of dredgings and fishing trials through a part of the Straits of Juan de Fuca.

The investigations were taken up on August 27 and terminated on September 4, having been carried through the strait from the longitude of New Dungeness to the vicinity of Cape Flattery. A large amount of life was obtained through the agency of the beam trawl, and a change in the character of the bottom fauna was observed as the mouth of the strait was approached, deep-sea types forming a more conspicuous feature of each haul. The surface, however, was found to be almost barren of life at this season, a few small crustaceans being about the only forms taken in the tow nets during the day, although large numbers of jelly-fishes came to the surface after dark. On August 28, between Neah Bay and Cape Flattery, a single specimen of the true cod (*Gadus morrhua*) was secured in the beam trawl, the first example of this species taken by the *Albatross* south of the Alaskan coast. The fishing trials were of great interest, but unfortunately they were not continued long enough to permit of entirely satisfactory conclusions respecting the extent of the fishery resources of this sheet of water. The work accomplished may be briefly summarized as follows:

On the first day the beam trawl was used from off New Dungeness to the neighborhood of Race Rocks in depths of 80 to 100 fathoms, and on August 28 six dredging stations were occupied in depths of 98 to 151 fathoms between Neah Bay and Cape Flattery. Two cod and two halibut trawl lines were also set on the latter date off Neah Bay in 80 to 100 fathoms of water, hand lines being employed at the same time. The currents proved too strong, however, for the successful use of either, and in the course of a few minutes the trawl buoys disappeared beneath the surface; they were not seen again. The weather was fine all day and the sea smooth, but during the dredging trials strong and erratic currents swept the ship about in the most extraordinary manner. Notwithstanding this fact, however, many flounders of excellent quality, together with other edible fishes and an abundance of shrimps and crabs, were taken in the beam trawl.

Greater precautions were taken with the fishing trials on August 29, and better success was obtained. One trawl line was first set in 140 fathoms, gravelly bottom, off Neah Bay, both ends being provided

with heavy grapnels and double buoys, and one end being also secured to a boat. The buoys were carried under by the current as on the previous day, but 100 hooks from the end attached to the boat were recovered, bringing with them three black-cod, the largest weighing 28 pounds. On a second trial in the same locality, both ends of the trawl line being secured to boats, the entire gear was recovered, the catch this time amounting to 14 black cod, averaging $12\frac{1}{2}$ pounds each in weight. Two dredging stations were made the same day in depths of 120 and 125 fathoms. The ship was then obliged to proceed to Victoria, British Columbia, in order to replenish the stock of fishing gear, but returned again to Neah Bay on the 31st.

The following day four sets with the trawl lines and four hauls of the beam trawl were made between Neah Bay and the Vancouver shore on the opposite side of the strait in depths of 136 to 152 fathoms. A cultus-cod weighing 29 pounds was captured in the beam trawl, the catch with the trawl lines comprising a few black cod, red rockfish, and dogfish, but in some places the currents were so strong that nearly all the hooks were stripped of their bait. Only a few dogfish were taken on the trawl lines during September 2 between Neah Bay and Pillar Point, but the beam trawl used in four positions, in 53 to 123 fathoms, secured an abundance of edible flounders and a dozen young cod. On the 3d three sets with trawl lines were made between Pillar Point and Port Angeles in 64 to 95 fathoms, taking only a few dogfish, and one dredging station was occupied in 92 fathoms. Flounders, herring, perch, butter-fish, sculpins, a salmon trout, and other species were secured by seining on the beach at the latter place.

The following day, the last one of the trip, was utilized in running a line of dredging and hand-line fishing stations diagonally across the strait from off Port Angeles to the vicinity of Victoria, the depths ranging from 40 to 46 fathoms. Nothing at all was taken with the hand lines, the currents being so strong that it was quite impossible to keep the hooks on or near the bottom, except close to land. Lieut. Commander Tanner concludes his account of this investigation as follows:

We have demonstrated the existence of several species of sea fishes in the open waters of the Straits of Fuca, and have also shown the impracticability of taking them in paying quantities by the usual methods. Should the black-cod ever take the place it deserves in the market, means will doubtless be devised for its capture, even in the straits. In the vicinity of Cape Flattery the currents reach the bottom with strong scouring effect, and the state of tides on the surface is no indication of their condition at the bottom. A heavy, confused swell will also be encountered, even in the calmest weather. Of course, this soon becomes modified after passing up the straits.

REPORT OF COMMISSIONER OF FISH AND FISHERIES. XCVII
SURVEY FOR A CABLE ROUTE BETWEEN CALIFORNIA AND THE
HAWAIIAN ISLANDS.

By an act of Congress approved March 2, 1891, special provision was made "To enable the President to cause careful soundings to be made between San Francisco, Cal., and Honolulu, in the Kingdom of the Hawaiian Islands, for the purpose of determining the practicability of the laying of a telegraphic cable between those points." This survey was placed under the direction of the Secretary of the Navy, but a suitable naval vessel not being available for the work, the services of the *Albatross* were requested, and by instruction of the President she was accordingly detailed for that purpose. While it was regarded as unfortunate that this steamer should so soon again be diverted from her legitimate fishery inquiries, there was cause for congratulation in the fact that so favorable an opportunity was thus presented to demonstrate once more her eminent fitness for this class of hydrographic investigations, similar surveys having previously been executed for the Navy Department by the same ship in the Caribbean Sea and about the Bahama Islands. In the field of work for which the *Albatross* was specially constructed, means for taking accurate soundings in all depths of water constitute one of the principal requirements in locating and defining the fishing-grounds, and to this end the most approved appliances have always been provided. In fact, no other vessel afloat is so perfectly equipped in respect to all inquiries relative to the physical and the natural-history features of the sea, and none has been more effectively employed, thanks to the untiring energy of her accomplished commanding officer.

Upon arriving at San Francisco from the Strait of Juan de Fuca the only material alteration required in preparation for the cruise was in the direction of increasing the coal capacity, which was readily accomplished by changing the laboratory storeroom into a temporary bunker. The ship was placed at the disposal of the Secretary of the Navy on September 18, but owing to delays, mainly caused by the necessity for awaiting supplies, the work was not actually taken up until October 9, 1891. Two lines of soundings were run, one toward the Hawaiian Islands, the other on the return trip, which was completed January 15 following. The results of the survey have been published in the form of a report to Congress by the Secretary of the Navy,* in which, doubtless through inadvertence, no credit is given to the Fish Commission for its participation in the work. A more detailed account of the cruise will be found in the report of Lieut. Commander Tanner, printed in the appendix to this volume.

* Report of the results of the survey for the purpose of determining the practicability of laying a telegraphic cable between the United States and the Hawaiian Islands, Fifty-second Congress, first session, Senate Ex. Doc. No. 153, 1892. 28 pp., and several charts, diagrams, and photographic reproductions.

A number of years previously the U. S. S. *Tuscarora* had run a line of soundings between San Francisco and the Hawaiian Islands, and it was proposed that the new line be made to the northward of the course taken by that ship, with stops for soundings at intervals of 10 and 2 miles. The plan finally adopted and carried out was suggested by Lieut. Commander Tanner, namely, to begin the line off Salinas Landing, in Monterey Bay, carry it thence through the deep gully which approaches the land very closely at that place, and having reached the open sea, to proceed practically along the arc of a great circle to the eastern end of Oahu Island, passing about 40 miles to the northward of the *Tuscarora's* submarine mountain, an elevation of about 1,400 feet above the surrounding ocean bed. The survey at the eastern shore end was first completed, and subsequently, with a full supply of coal, the main part of the line was run between the dates of November 7 and 21. From 10 to 12 soundings were generally made each day, the depths, outside of the continental platform at each end, ranging from 2,000 to over 3,000 fathoms, except in a few instances. The ship remained about the Oahu Island until December 11, surveying a route for the shore end of the cable, making some needed repairs, and conducting natural-history investigations by means of the beam trawl and tangles. The naturalists also took advantage of the opportunity to secure a large and fine collection of the shore fishes.

Realizing the importance of obtaining still further information respecting the contour of the ocean bottom between the two countries, and having no instructions to the contrary, Lieut. Commander Tanner, on leaving the Hawaiian Islands, carried a second line of soundings eastward along a rhumb line which intercepted the great-circle line about 35 miles off Salinas Landing. On neither of these lines did the ship encounter the submarine elevation discovered by the *Tuscarora*.

Stormy weather was met with during both trips, and it was especially severe during the second one. The completion of the survey was greatly delayed in consequence, and the ship was subjected to unusual strain and wear, but escaped any severe damage. After reaching San Francisco orders were issued to make preparations for a third sounding trip, this time between Point Conception and Hilo, on the island of Hawaii, and the necessary repairs were at once begun, but by the time they had been completed the ship was required for other service. The U. S. S. *Thetis* was therefore substituted in her place, and the *Albatross* was returned to the Fish Commission on March 12, 1892.

During the cable survey, in addition to the ordinary sounding work, the samples of the bottom brought up in the cup were examined microscopically; the temperature of the water at the surface and bottom was constantly observed, series of intermediate temperatures were taken occasionally, and the density of the surface water was frequently determined. The rhumb line run by the *Albatross* has been considered to have developed the most favorable conditions for a cable route.

FUR-SEAL INVESTIGATIONS.

On March 15 the *Albatross* was detailed to assist in securing information required in preparing the case of the United States respecting the fur-seal fishery of the North Pacific Ocean and Bering Sea, to be submitted to the Paris Tribunal of Arbitration, for which arrangements were then in progress. This work continued until the end of the fiscal year and was under the nominal direction of the Secretary of the Treasury, although the instructions relative to the investigations emanated from the State Department and the Fish Commission. The ship left San Francisco on March 20, proceeding first to Port Townsend, where she was joined by Prof. B. W. Evermann, as chief naturalist, and Mr. Joseph Murray, special Treasury agent. The services of an interpreter for the Alaskan dialects and of two seal-hunters were also secured. Mr. C. H. Townsend, naturalist of the *Albatross*, and Mr. A. B. Alexander, fishery expert, were attached during a part of the season to the revenue steamers *Corwin* and *Bear*, both of which vessels had been dispatched upon similar missions.

The principal objects sought to be attained through the agency of the *Albatross* were to ascertain if the fur seal has other hauling-grounds than the Pribilof Islands on the Alaskan coast; to determine what, if any, relations exist between the American and Asiatic herds, and to learn as much as possible regarding the habits and movements of these animals during their migrations northward. The necessity of moving rapidly from place to place, however, prevented satisfactory observations relative to the pelagic habits of the seals, but in other respects the duties assigned to the ship were successfully accomplished.

Starting from Port Townsend on March 31, a course was set to carry the ship over the usual sealing-grounds at this season off Vancouver Island, but owing to stormy weather only occasional seals were seen, either singly or in groups of two and three. Cook Inlet, Kadiak, and Prince William Sound were visited in the order named, and the experienced native hunters and few white inhabitants were interrogated at each place. In regard to Cook Inlet, Lieut. Commander Tanner makes the following statement, which applies also to the other places mentioned:

The question as to whether fur seals were ever known to haul out in or near Cook Inlet was among the many interesting subjects presented for solution. Inquiries were made among men who have passed their lives in hunting over the region under discussion, and the fact that none of them ever saw a seal hauled out would seem to settle the question conclusively. The fur seals pass along the shores, and sometimes enter Cook Inlet in small numbers when they are on their way to Bering Sea; they sometimes loiter about a few days, and then an occasional one is killed, providing there are no sea otter about; but should the presence of the latter be suspected, the seals will remain undisturbed by the otter hunters.

The past winter had been the most severe one known for many years, causing much suffering, and this was subsequently found to be the case at all places in Alaska visited by the *Albatross*. During one day

hand-line fishing was tried on a bank several miles off Soldovoi, at the mouth of Cook Inlet, where, according to tradition, cod and halibut are exceedingly abundant. The bottom indications proved favorable for those species, but no fish were taken, and if they resort to this locality it is probably at some other time of the year. The region is worthy of further examination, especially in view of the proximity of good harbors, native settlements, and supplies of wood, coal, and fresh water.

About Port Etches, Prince William Sound, cod and herring were found to be abundant, the former species being taken by the natives. Specimens were caught from the deck of the *Albatross* by means of hand lines, and, although rather small in size, they were of good quality. Herring were also captured in considerable numbers by seining along the shores. The pursuit of the sea otter has been the principal occupation of the natives at this place, as in Cook Inlet and along most of the coast and islands further westward.

Before starting on the return trip to Port Townsend, a short time was spent in investigating the positions of several dangers to navigation which have been reported to exist in this region. Hydrographic office chart No. 527 shows a rock in latitude $59^{\circ} 31' N.$, longitude $144^{\circ} 43' W.$, where, however, the *Albatross* failed to discover it. In 1888 the *Albatross* also disproved the occurrence of Pamplona Rocks in one of the positions assigned to them, namely, latitude $59^{\circ} 03' N.$, longitude $142^{\circ} 40' W.$, and it now proceeded to run a careful series of soundings with respect to the other position given, in latitude $59^{\circ} 35' N.$, longitude $143^{\circ} 04' W.$ In this locality, however, the least depth observed was 114 fathoms, the greatest being 504 fathoms. The results of the survey are thus described by Lieut. Commander Tanner:

The various courses during the day practically paralleled those of 1888, when the *Albatross* made her first search for the rocks, and, both days being clear during the time of search, the masthead lookout would have noted anything above water at least 10 miles on either hand; hence we may conclude that these vigias do not exist within the belt 40 miles in width and 100 in length, over which our reconnoissance extends.

A brief stop only was made at Port Townsend, the ship proceeding thence, on May 10, directly to Unalaska, which was reached on the 18th. On the 22d of the same month the *Albatross* left the latter place for a cruise to the westward among the Aleutian Islands and as far as the Commander Islands off the Siberian coast, during which much important information was gathered regarding the fur seals and the fishes along that route. The settlement at Nazan Bay was reached while the hunters, who follow the sea otter among the Andreanof and Kryci (Rat) islands, were still at home. The Atka mackerel (*Pleurogrammus monopterygius*), an excellent food-fish, is here taken to a limited extent and constitutes an important item in the native food supply. It appears on the shores of the Aleutian Islands, from Atka westward, in the spring, in large schools, which hover closely about the kelp beds,

especially favoring the passes or exposed points where strong currents prevail. This habit would preclude the use of purse seines for their capture, but they can readily be taken by other methods. With respect to seals, Lieut. Commander Tanner states:

The agent and several of the older and most intelligent hunters testified regarding the movements of fur seals, and were unanimous in the opinion that the herds do not use the passes between Amukta and Great Kiska islands in their migrations to and from Bering Sea. Only scattering seals have been seen by them in the Andrea-nof and Kryci islands, and they were mostly gray pups, which appear from September to November, usually after northerly gales; they are never seen during the winter. They are captured whenever opportunity offers, and the flesh used for food, it being considered a great delicacy; the skins are either used for domestic purposes or sold to the company. A dozen seals a year would probably be a fair average for the Atka hunters.

Attu Island was next visited. The occupation of the natives is the same here as at Nazan, the hunting-grounds embracing their own island, Agattu, and the Semichi group. This was formerly a rich station, but the sea otters have been steadily decreasing in abundance, and are now scarce. Halibut are taken in small quantities in the spring, while cod are present at all seasons. The Atka mackerel is abundant from April to September and forms an important article of food. The condition of the people at this place, especially the women and children, was so deplorable from the lack of proper food, owing to the severe winter, that sufficient rations were issued to them from the *Albatross* to relieve their wants until the arrival of the supply vessel. The native hunters, according to Lieut. Commander Tanner, were practically unanimous on the following points:

Fur seals are seldom seen about Attu, Agattu, and the Semichi Islands, and they have never been known to haul out except when wounded; two or three instances are remembered of wounded seals having been shot while hauled out to rest. Twenty-five or thirty years ago the older hunters recollected seeing them in small squads about the kelp beds, during the month of June, feeding on Atka mackerel. They never saw any seals east of the Semichis, nor had they ever seen any about during the winter season.

It will be remembered that the Atka hunters did not believe that the Pribilof herd used the passes west of Amukta Island; the Attu men never saw fur seals east of the Semichi group, and the *Albatross* experience in traversing the whole length of the Aleutian Archipelago from Unalaska to Attu without seeing even a single individual seems to confirm the native belief that the Commander Islands herd do not enter or leave the sea east of Attu and the Pribilof herd do not enter or leave west of the Four Mountain Pass.

A line of soundings was run May 29 and 30 across the wide entrance into Bering Sea from Attu Island, the westernmost of the Aleutian chain, to Copper Island, of the Commander group. Only deep water was found in this space, the maximum depth discovered being 1,996 fathoms, about 30 miles off Copper Island. The Commander Islands are located at the eastern edge of the continental platform off the Kamchatkan coast, and apparently have no direct connection with the Aleutian chain.

On May 31 the *Albatross* reached Nikolski, on Bering Island, the

residence of the governor, Col. N. A. Grebnitzky, who had been advised by his government of the mission of the ship, and who did everything in his power to render it successful. The experienced native hunters on these islands are convinced that the seals which resort to the Pribilof and Commander islands do not mingle, and that those on the western side spend the winter along the Kurile Islands of Japan. The authorities also stated that the fur seals were fast decreasing on the rookeries of the Commander Islands, which fact they attribute to the indiscriminate slaughter of all ages and sexes by the pelagic sealers. Specimens were obtained from one of the rookeries on Bering Island for comparison with others from the eastern herds. The naturalists secured from one of the natives a very nearly perfect skeleton of the extinct Arctic sea cow (*Rhytina stelleri*), which is now in possession of the U. S. National Museum in Washington. A partial survey of Nikolski Bay was likewise made by the *Albatross*. The ship proceeded on June 3 to Copper Island, where observations were made on Polatka rookery, and some additional seal specimens were obtained.

The population of the Commander Islands at the time of the visit of the *Albatross* was 656, 20 being whites and the remainder natives. The management of affairs here is excellent and constant employment is given to the inhabitants, all of the able-bodied men and larger boys being occupied on the rookeries during the sealing season and in hunting the blue fox in the winter. Protection for the rookeries is provided in the following manner:

A small guard is maintained for watching over the rookeries. The privates are selected from the native youths between the ages of 15 and 21; they serve three years without further compensation than their share of the family fund. The non-commissioned officers are Russians. While the guards are stationed at the rookeries they occupy barabaras, usually situated on the bluffs overlooking the beaches, and are not allowed to approach a rookery except to repel poachers. It is their first duty to give the alarm in case boats are seen approaching and warn them off. If the warning is not heeded, they are to drive the seals into the water, and if the poachers still persist in landing or do not depart, they are to fire upon them, using sufficient force to drive them away.

The regulations enforced on the seal rookeries of the Commander Islands are more stringent than those relating to the Pribilof group, and the same is also true with respect to sea-otter hunting as compared with the waters within the jurisdiction of the United States. There is a close season for sea otters extending from June 1 to February 1 of each year (according to the Russian calendar), and during the open season the number which may be taken is prescribed. On and about the sea-otter rookeries only spears and nets are allowed to be used, firearms being permitted only at distances of 5 or more versts from the rookeries. Females and yearling pups caught in the nets must be set free. All persons are forbidden to go on or near the sea-otter rookeries during the breeding season; neither shall they make a camp on or near a rookery during the same period, nor build a fire, or be the cause of any kind of smoke.

Fifteen reindeer introduced on the islands in 1881 have increased to about 300, and the herd is still protected. The natives also have small herds of Siberian cattle, which are hardy and find ample subsistence the year round. Lieut. Commander Tanner suggests that the same breed of cattle might advantageously be introduced on the inhabited islands of the Aleutian chain, where the rapid extinction of the fur-bearing animals will soon make it difficult for the natives to obtain food. This important matter deserves prompt consideration.

From Copper Island the *Albatross* returned to Port Townsend by way of Unalaska, and on June 30 she left Departure Bay, British Columbia, where she had been coaling, on another cruise to Bering Sea.

Between July 1, 1891, and the same date in 1892 the *Albatross* was at sea 206 days, during which time she steamed 24,991 knots and made 601 soundings, mostly in the deep sea, 39 dredgings, and 30 tow-net stations, the intermediate tow net being employed at many of the latter in considerable depths of water.

ATLANTIC COAST.

OYSTER INVESTIGATIONS IN CHESAPEAKE BAY.

Tangier and Pocomoke sounds.—The survey of this important oyster region begun on May 15, 1891, was continued until November 28 following, when, owing to inclement weather and the presence of many fishing boats upon the grounds, it was closed for the year, although the dredging trials had not been entirely completed. It is proposed to finish the latter during the summer of 1892. The scope of this investigation and the plans adopted for carrying on the work were described in the last annual report. Similar inquiries had been conducted in the same waters by Lieut. Francis Winslow in 1878 and 1879 and by Dr. W. K. Brooks a few years later, and it was expected that by repeating the examinations conclusions might be reached of more than local significance.

The work was carried on by means of the steamer *Fish Hawk*, Lieut. Robert Platt, U. S. Navy, commanding, and the steam launch *Petrel*, the latter replacing the *Fish Hawk* during its temporary absence in connection with the experiments relative to the hatching of the Spanish mackerel, and subsequently remaining on the grounds until the end of the season, being required for the examination of the shallow-water areas which could not be reached by the larger vessel. In many places, moreover, it became necessary to resort to the use of small flat-bottomed boats, especially near the shores and between the islands. Mr. John D. Battle acted as chief assistant in the hydrographic work and also had charge of the observations upon the material secured by dredging. He was aided by Mr. J. Percy Moore, of the University of Pennsylvania, until September 1; by Mr. B. L. Hardin and by Mr. W. C. Kendall after the middle of July. In addition to his other duties Mr. Moore spent considerable time in conducting special researches

respecting the biology of the oyster. A person well acquainted with the oyster-grounds of the region was also employed as an oyster pilot.

Owing to the fact that nearly all the original triangulation points established by the Coast and Geodetic Survey had disappeared and that the coast lines had been materially altered by currents since the construction of the charts now in use, some delays occurred in the placing of new signal stations, which it was necessary should be located with much care to insure accuracy in the positions of all dredging and sounding stations. The region was divided into three sections, to be investigated in succession, the instructions being to complete the work in one before beginning upon another. The southern half of Tangier Sound, between its mouth and latitude 38° N., was first taken up and the hydrographic observations relating to it were practically completed by July 18. Between that date and August 1 the examinations were carried over the very shoal area between Tangier and Smith islands; some time was spent in studying the advantages of the region for the establishment of an experimental oyster station, which is much needed; and lines of density observations were run back and forth across the sound at different times of the tide. The *Fish Hawk* having returned by this time, the dredging investigations were started August 3 and were completed on the 28th of the same month.

Beginning then in the northern part of Tangier Sound, the inquiry was continued there until October 22, the hydrographic and density observations as far north as Clay Island light-house, and including also Manokin and Great Annemessex rivers, being completed by that date, as well as some of the dredging lines. The regular oyster-fishing season, however, had opened in the meantime and hundreds of dredging boats were at work, making it impossible to carry on the investigation in a continuous and satisfactory manner. It was also considered that the thorough raking which the grounds were then receiving would render the results to be obtained by the dredgings of the *Fish Hawk* of little value for comparison, so the vessel proceeded to Pocomoke Sound, where the month of November was spent in delineating the oyster beds. In this shallow area of water the *Fish Hawk* was only useful as a base of operations, the work being entirely carried on by means of the steam launches and rowboats. No dredging was attempted.

By the methods employed in conducting this investigation the outlines of the oyster-grounds, the areas of rank and scattered oyster growth, and the barren grounds were all determined and marked out as a part of the sounding work, the dredge being used to supplement the results thus obtained, to ascertain the actual proportion of living oysters to dead shells, the relative number of each size, the amount of spat, and the general condition of the grounds. The proportions were calculated to the square yard, the dredge employed having a width of exactly 3 feet in the opening of the mouth and the distance over which it was dragged each time being accurately determined. As this branch of the work was completed in the southern half of Tangier Sound just

before the opening of the oyster season, the information obtained can be relied upon to show the true condition of the grounds in that region during the latter part of the customary period of rest which is allowed them every year.

A final report upon this survey has not yet been prepared for publication, but the principal results obtained, including maps illustrating the outlines of the oyster beds and the relative abundance of oysters in different parts of the two sounds, have been communicated to the governors of Maryland and Virginia, both of which States are now considering measures for the improvement of their oyster fisheries.

In addition to his regular duties in recording the character and condition of the material obtained by dredging, Mr. Moore made many interesting observations upon the younger stages of oysters following their fixation and until their shells had attained a diameter of three-quarters of an inch. He also succeeded in rearing the embryo oysters as far as the larval-shell period, when they all suddenly disappeared, as they did in the experiments made by Prof. John A. Ryder and Lieut. Francis Winslow. No light was thrown upon the causes of this disappearance.

Mobjack Bay.—During the last of May, 1892, an oyster survey, identical in its purposes and methods with that conducted the previous year in Tangier and Pocomoke sounds, was begun in Mobjack Bay, Virginia, the launch *Petrel* being detailed to make the delineation of the oyster beds and adjacent bottom, over which it was intended to run dredging lines later in the season by means of the steamer *Fish Hawk*. This investigation was still in progress at the close of the fiscal year, at which time the sounding operations in the bay proper were well under way, but it was expected that some time would be required to finish the survey in the tributary creeks, which contain beds of considerable importance. The work was in charge of Mr. John D. Battle, assisted by Mr. W. F. Hill and Mr. B. L. Hardin.

Delineation of public oyster-grounds by Virginia.—During the spring of 1892, under an act of the State legislature, arrangements were completed by the governor of Virginia looking to the delineation or marking off of the natural oyster beds in the waters of that State by right lines, with the ultimate object of retaining the areas so inclosed as public grounds and of granting the use of any suitable bottoms outside of those limits to individuals for oyster cultural or planting purposes. The benefits to be derived by fixing the outlines of all grounds held open to the public, so that their boundaries may readily be determined at any time by bearings from the shore or by sextant angles, unless, in fact, they be actually buoyed out, and by establishing their status permanently through legislative enactment to avoid constant interference through the courts, will be thoroughly appreciated by everyone who feels a genuine interest in the advancement of this important fishing industry.

The State is to be congratulated on having at last taken the initial step toward restoring, on a proper basis, those extensive resources which have been so rapidly depleted and which, by judicious management, can be made to yield the State a large revenue. State officers will be selected to act in conjunction with an engineer, who is to be detailed by the Superintendent of the U. S. Coast and Geodetic Survey, in running the necessary lines and preparing the maps required. The careful investigations now being made by the U. S. Fish Commission relative to the oyster-grounds of Chesapeake Bay have been accepted as the basis for the proposed delineations, so far as they apply to the waters of Virginia, and may be finished in time to serve the purposes of the State. Arrangements have also been made to allow the State authorities the use of one of the Fish Commission launches during the summer of 1892.

The food of oysters.—With the object of obtaining some needed information concerning the food of oysters, and the relations of oysters to their environment in that respect, the services have been secured of Dr. John P. Lotsy, of Johns Hopkins University, who will spend the months of July, August, and September in making a study of this subject in the vicinity of Hampton, Va. Dr. Lotsy is a native of the Netherlands, where he had considerable experience in connection with oyster-cultural experiments before coming to this country. Questions relative to the feeding of the oyster have, however, already received much attention from employes of the Fish Commission, and several important contributions bearing upon this subject will be found in its publications.

THE PRODUCTION OF SEED OYSTERS.

Before the close of the fiscal year arrangements had been made with Dr. John A. Ryder to continue some novel experiments respecting the collecting of oyster spat by a new system, which had been given a partial trial during the previous summer at the marine biological laboratory of the University of Pennsylvania, located at Sea Isle City, N. J. The system in question consists in distributing oyster shells or other materials suitable for the fixation of the spat over horizontally placed wire screens, supported on posts near the surface of the water in close proximity to beds of oysters. The advantages claimed for this method are, the more favorable position given to the collecting surfaces and the fact that areas of muddy bottom not suitable for oyster planting can also be utilized for this purpose. In case natural oyster beds are not properly situated for supplying the spat desired, artificial beds can be arranged on similar platforms, at a lower level than the collecting surfaces, during the spawning season. The cost of the plant is comparatively little, and the success met with in 1891 encourages the hope that the experiments may lead to results of practical importance.

FISHERY INVESTIGATIONS IN CHESAPEAKE BAY AND ADJACENT WATERS.

In the latter part of June, 1892, the schooner *Grampus* was detailed to conduct investigations in the lower part of Chesapeake Bay and in the adjacent waters of the open ocean, with the special object of determining the distribution and abundance of fishes throughout that region. The inquiry was in charge of Capt. A. C. Adams, commanding the *Grampus*, with Mr. W. C. Kendall as naturalist, and it was continued into the next fiscal year. The vessel has been fitted out with dredges, beam trawls, trawl and hand lines, and with the necessary instruments for observing the temperature and density of the waters. Being without steam power, however, it is not expected that very effective work can be accomplished by dredging, and collecting will chiefly be carried on by the ordinary methods of the fishermen. Scarcely anything has hitherto been done in the region indicated in the way of studying the bottom fishes, although the field is one of great importance in view of the extensive commercial fisheries which it has supported for a long period. Occasional dredgings were made some years ago within the limits of the bay by the steamer *Fish Hawk*, and on the ocean bottom outside by the steamer *Albatross*, but those investigations contributed little information of direct practical importance.

PHYSICAL INQUIRIES.

The physical inquiries which had been carried on off the southern coast of New England during the previous two summers, under the direction of Prof. William Libbey, jr., of Princeton College, were continued during the season of 1891, from June 30 until September 1. As the Coast Survey steamer *Blake* could not be spared again for this work, the lines of observing stations were run exclusively by the schooner *Grampus*, the light-ship on Nantucket New South Shoal being also utilized as before, through the courtesy of the Light-House Board, for the taking of supplementary observations. Prof. Libbey remained in charge of operations, and was assisted by Prof. M. McNeill, Prof. C. G. Rockwood, Prof. H. B. Thomson, Mr. S. T. Dodd, Mr. L. S. Mudge, and Mr. W. H. Dodd.

The work was conducted on essentially the same plan as in 1889 and 1890, but as only one vessel was employed the scope of the observations was materially less than in the latter year. A complete account of the methods pursued will be found in the last annual report. The principal object of the investigation is to determine the physical characteristics of the belt of water bordering the coast through which many important fishes pass during their seasonal migrations north and south, the changes occurring therein, and the causes producing such changes. To accomplish this purpose it is necessary to obtain at different times of the season many parallel series of surface and intermediate tem-

CVIII REPORT OF COMMISSIONER OF FISH AND FISHERIES.

perature observations at right angles to the shore line, together with corresponding meteorological observations for comparison with them. It is expected that Prof. Libbey will soon be ready to announce the results of the work so far completed.

The Light-House Board and the Southern Pacific Railroad Company have continued to coöperate with the Fish Commission in securing continuous series of water-temperature observations at many places along the Atlantic seacoast and on some of the Western rivers. This service is rendered gratuitously, and in the case of the light-house keepers at least at their own personal volition, not being regarded as a part of their regular or official duties. The records now on hand cover a period of many years, and are of great value in connection with the study of the migratory habits of our food-fishes. Mr. H. R. Center is now engaged in making reductions of the daily observations to averages of ten-day periods for publication in tabular form. The places at which observations were made during the past year are as follows:

Temperature stations on the Atlantic coast.

Stations of the Light-House Service:

Coast of Maine: Petit Manan Island, Mount Desert Rock, Matiniens Rock, Seguin Island, Boon Island.

Coast of Massachusetts: Race Point, Pollock Rip light-ship, Great Round Shoal light-ship, Nantucket New South Shoal light-ship, Cross Rip light-ship, Vineyard Sound light-ship.

Coast of Rhode Island: Brenton Reef light-ship, Block Island southeast light. Long Island Sound: Bartlett Reef light-ship, Stratford Shoal light-ship.

Coast of New York: Sandy Hook light-ship.

Coast of New Jersey: Absecon Inlet light, Five-Fathom Bank light-ship.

Delaware Bay: Fourteen-Foot Bank light-ship.

Coast of Virginia: Winter Quarter Shoal light-ship.

Chesapeake Bay: Windmill Point, Stingray Point, Wolf Trap Bar, York Spit.

Coast of North Carolina: Bodys Island, Cape Lookout, Frying Pan Shoals light-ship.

Coast of South Carolina: Rattlesnake Shoals light-ship, Martiu's Industry Shoal light-ship.

Coast of Florida: Fowey Rocks, Carysfort Reef, Dry Tortugas.

Stations of the Fish Commission:

Gloucester and Woods Holl, Mass.

Fort Washington and Bryan Point, Potomac River, Maryland.

Washington, D. C.

Temperature stations of the Pacific Slope.

Stations of the Southern Pacific Company:

Sacramento River, at Tahama and Yolo Bridges and Kings Landing, Cal.

Feather River, at railroad crossing, near Marysville, Cal.

American River, at railroad crossing, California.

Mokelumne River, at Lodi, Cal.

Tuolumne River, at Modesto, Cal.

San Joaquin River, at the upper and lower railroad crossings, California.

King River, at Kingsbury, Cal.

Colorado River, at Yuma, Ariz.

The Fish Commission is under obligations to the U. S. Weather Bureau for the comparison with standards of a series of Negretti and Zambra deep-sea thermometers, and for information supplied for the use of Prof. Libbey in connection with the physical investigations of the schooner *Grampus*.

WOODS HOLL LABORATORY.

The laboratory at the Woods Holl Station of the Fish Commission was opened as usual for the summer season on July 1, 1891, but several persons arrived there and began their studies during the previous month. The biologists in attendance were Dr. H. V. Wilson, assistant in charge of the laboratory; Prof. F. H. Herrick, of Adelbert College, Cleveland, Ohio; Prof. William Patten, of the University of North Dakota; Dr. James L. Kellogg and Dr. E. J. Conklin, fellows of Johns Hopkins University; Dr. W. McM. Woodworth, instructor in Harvard University; and Prof. H. T. Fernald, of the State College of Pennsylvania. The Commissioner and Dr. T. H. Bean, ichthyologist of the Commission, were also present during most of the summer, and Prof. William Libbey, jr., with his assistants on the schooner *Grampus*, were at the station from time to time.

Dr. Wilson, who has been employed at the laboratory continuously since May, 1888, was engaged chiefly in the study of the embryology of certain sponges, preparatory to a visit to the coast of Florida, which it was proposed to make the following winter, with the object of investigating the development of the commercial sponges and of conducting experiments relative to their artificial propagation. On August 31, however, he resigned his position on the Commission to accept the chair of biology in the University of North Carolina, much to the regret of his associates. Prof. Herrick continued his researches on the life-history of the lobster, paying most attention to the phenomena which accompany the metamorphoses of the younger stages. Prof. Patten was chiefly occupied with observations respecting the variety of ways in which the embryo of *Limulus*, or the horseshoe crab, develops, finding the number of abnormal embryos and the grades of abnormality to be unusually large with this peculiar species. Messrs. Kellogg and Conklin were at work upon the anatomy, embryology, and habits of several edible and harmful mollusks, important species in connection with the commercial fisheries of the Atlantic coast. Their inquiries in this direction had been taken up previous to this summer, and were continued later in the year at the laboratory of Johns Hopkins University.* Prof. Fernald made a study of the development of several crabs, and Mr. Woodworth continued for a few weeks his researches on the life-history of the parasitic planarian which infests the gills of *Limulus*.

*A contribution to our knowledge of the morphology of Lamellibranchiate mollusks. By James L. Kellogg, PH. D. Bull. U. S. Fish. Comm., x, for 1890, pp. 389-436, plates LXXIX-XCIV.

Mr. Vinal N. Edwards, who has been attached to the Woods Holl Station since it was first established in 1871, continued during the entire year his observations upon the natural history and temperature of the waters in this region, in addition to the assistance which he rendered in connection with the fish-cultural work. His duties in the line of scientific inquiry consist in keeping a daily record of all fishes present in this neighborhood, so far as the same can be determined by observing the catches made by the fishermen, and by making frequent collecting trips with seines, gill nets, tow nets, etc., to all parts of Vineyard Sound, Buzzards Bay, and other neighboring waters.

One of the most important and significant discoveries which he has made in recent years relates to the spawning habits of the menhaden. The very young of this species abound during the entire summer in the brackish waters of several creeks or small rivers which empty into Buzzards Bay, such as the Acushnet River and the Wareham River, and their incredible numbers, taken in connection with their small size, precludes their having entered these streams from the sea. The adult menhaden come into these waters to spawn in the spring, but what has diverted attention from this habit is the fact that they do not school at the surface at that season, and consequently their early movements have generally escaped the notice of the fishermen. Since Mr. Edwards first made known these observations information has been received that the young have been found just as abundantly in similar situations on the coast of New Jersey and in Chesapeake Bay, and a careful search would undoubtedly disclose their presence along the entire range of coast to which the menhaden resort. Whether or not the spawning takes place exclusively in the spring has not been determined, but nearly ripe menhaden have been captured in the fall, and it is possible that the season is different on different parts of the coast. Observations relative to this very interesting problem will be actively prosecuted during next year.

Before the end of June, 1892, a number of naturalists had already arrived at the Fish Commission laboratory, and work was actively in progress in advance of the regular opening day for the next season, July 1. Dr. James L. Kellogg had been employed temporarily to take charge of the laboratory during the summer of 1892, and reached there on June 3. Others present before the close of the fiscal year were Prof. F. H. Herrick, Prof. William Patten, Dr. H. V. Wilson, and Mr. Maynard M. Metcalf, of Johns Hopkins University.

Many additions made to the laboratory during the past year in the way of appliances for research, books of reference, etc., have greatly increased the facilities for work. Numerous courtesies have been extended to the Marine Biological Laboratory, which is adjacent to the Fish Commission station, and many favors in return are to be acknowledged.

INVESTIGATION OF INTERIOR WATERS.

MONTANA AND WYOMING.

Extensive investigations were conducted in Montana and Wyoming by Prof. B. W. Evermann during July and August, 1891, in compliance with a provision of the sundry civil appropriation bill for the fiscal year 1891-92, with the object of determining the advisability of establishing a fish-hatching station in the Rocky Mountain region in one or other of the States mentioned and of making observations relative to the selection of a proper site for such a purpose. From a previous knowledge of the region it was decided that the best conditions for such a station as had been contemplated would be found either in the western part of Montana or the northwestern part of Wyoming, and the examinations were therefore limited to the area so defined, which is drained by the head waters of both the Columbia and Missouri rivers, having their origin on the great continental divide. Prof. Evermann was assisted in his field work by Prof. O. P. Jenkins, of the Leland Stanford, jr., University, and Mr. Burnside Clapham, of Monroeville, Ind. Supplemental inquiries, having reference mainly to the lower forms of life living in the same waters, were also carried on by Prof. S. A. Forbes, of Illinois, later in the season.

In order to comply fully with the requirements of the case, it was necessary to conduct this survey on a somewhat more comprehensive basis than had been usual in the past, comprising a careful study of the physical features of all the important lakes and water-courses and of the different fishes which inhabit them, whether useful or otherwise, together with the conditions of environment now existing or essential to their welfare, as also to that of other species which it might be deemed advisable to introduce, and, likewise, the detailed examination of all places which might appear suitable for fish-cultural operations of the character proposed.

The following account of the water systems of this region is extracted from the report of Prof. Evermann: *

By far the greater part of Montana, nearly all that portion lying east of the meridian of 112° 30', lies within the Missouri drainage area. In the northwest portion of the State the divide lies more than a degree farther west, and in the southwest the Missouri drainage extends westward to the Idaho State line. The Missouri also drains all of northwest Wyoming, excepting the southwest portion of the National Park and part of the region south of the Park. This part of Wyoming belongs to the Columbia River basin, being drained directly by the Snake River and its tributaries. In general it may be said that the streams of the Missouri system flow in

*A Reconnaissance of the Streams and Lakes of Western Montana and Northwestern Wyoming, by Barton W. Evermann, PH. D. Published first as a Congressional document in Report of the Commissioner of Fish and Fisheries respecting the establishment of fish-cultural stations in the Rocky Mountain region and Gulf States, 1892 (Fifty-second Congress, first session, Senate Mis. Doc. No. 65, 58 pages, 27 plates), and reprinted in the U. S. Fish Comm. Bull., vol. XI, for 1891, pp. 3-60, plates 1-27.

a northeast or northerly direction. Those tributary to the Clarke Fork of the Columbia flow to the northwest, while the drainage into the Snake River or Lewis Fork of the Columbia is to the southwest.

Nearly all of these rivers and creeks are, of course, swift mountain streams; most of them have their rise in small lakes of clear, cold water, high up in the mountains—lakes which as yet are difficult of access and but little known. Many of these lakes are known, however, to be well supplied with trout, while others are wholly without any fish life whatever. From these mountain lakes the swiftly-flowing, turbulent streams make their descent through rocky gorges and canyons to the valleys below. Ordinarily the beds of the streams are very rocky, but now and then are found more quiet reaches where the streams have sand or gravel beds as they flow through small mountain meadows. Then, at other places, there are rapids and cascades, and in many of the streams are found considerable waterfalls. The best illustrations of this are in the numerous magnificent falls found in the streams flowing from the great volcanic plateau constituting the larger part of the Yellowstone National Park. As the streams leave this immense sheet of rhyolite they do so in great falls, such as those of the Yellowstone, Gibbon, and Lewis rivers. Others of the same nature are to be found in the country lying to the east of the National Park, in the Clarke Fork of the Yellowstone, and other streams of that region. These falls, of course, serve as more or less effective barriers to the distribution of fish, and as a result many of the mountain lakes, though of the most suitable character, so far as temperature, purity, and abundance of food supply are concerned, are wholly barren of fish life of any kind. The larger streams are, as a rule, less swift, and have more sandy and gravelly beds. There are few, if any, sluggish streams in this region, and all are clear, unless contaminated by mining operations.

In the Columbia River basin twenty-four lakes and streams tributary to the Clarke Fork and nine tributary to the Lewis Fork were examined by Prof. Evermann; in the Missouri River basin the examinations extended to twenty-six tributaries of the Yellowstone River and Lake, the Madison, Gallatin, and Jefferson rivers, and Prickly Pear Creek. Descriptions are given of the principal features characteristic of each of these waters, and their fishes are discussed.

One of the most interesting incidents of the expedition was a trip to Two-Ocean Pass, where the waters of the Columbia and Missouri rivers virtually meet and provide a limited passageway for fishes from one to the other. Visits had previously been paid to this locality, which is situated just south of the southern border of the Yellowstone National Park, by a few travelers who have given accounts of its peculiarities, but although Prof. Evermann was there only a short time his observations have enabled him to explain its features more completely and accurately than any of his predecessors, whose descriptions of the place are greatly at variance with one another. His report contains a plan and sketch illustrating the true relations existing between the several streams.

According to Prof. Evermann—

Two-Ocean Pass is a nearly level piece of meadow land, surrounded by rather high hills except where the narrow valleys of Atlantic and Pacific creeks open out from it. Running back from the hills to the northward are two small canyons; on the opposite side is another canyon of the same character. Down these canyons come the three main streams which flow through the pass. The extreme length of the pass from east to west can not be much less than a mile, while the width from north to south is perhaps three-fourths of a mile.

After describing the creeks and the character of their connections in detail, he adds:

Pacific Creek is a strong stream long before reaching the pass, and its course through the meadow is well fixed, but not so with Atlantic Creek. The west bank of each fork [of Atlantic Creek] is liable to break through almost anywhere, and thus send a part of its water across to Pacific Creek. It is probably true that one or more branches connect the two creeks under ordinary conditions, and that in times of high water a very much greater portion of Atlantic Creek flows across to the other. At any rate, it is certain that there has been, and usually is, a free water-way through Two-Ocean Pass of such a character as to permit fishes to pass easily and readily from the Snake River over to the Yellowstone—or in the opposite direction. Indeed, it is possible, barring certain falls, for a fish so inclined to start at the mouth of the Columbia, travel up that great river to its principal tributary, the Snake, continue on up the long, tortuous course of that stream, and, under the shadows of the Grand Tetons, enter the cold waters of Pacific Creek, by which it could journey on up to the very crest of the Great Continental Divide, to Two-Ocean Pass. Through this pass it may have a choice of two routes to Atlantic Creek, where it begins the journey down stream. Soon it reaches the Yellowstone River, down which it continues through Yellowstone Lake, then through the Lower Yellowstone out into the turbid waters of the Missouri.

Small trout of the species belonging on the western slope (*Salmo mykiss*) were abundant in both Pacific and Atlantic creeks, but the blob, or miller's thumb, which occurs in the former, was not observed in the latter, nor in the waters into which it flows lower down. The high falls in the Lower Yellowstone River, however, preclude the ascent of fishes from the Missouri River basin, and the Upper Yellowstone River, together with the lake of the same name, was evidently stocked from the west, and almost certainly by way of Two-Ocean Pass.

By diligent collecting at the various places visited by the party a fair representation of the fish fauna was undoubtedly obtained, but owing to the mountainous character of the region and the clear, cold waters and rapid currents of most of the streams it was not to be expected that a great variety of forms would be found. Only sixteen indigenous species were secured, besides four species which had been introduced by the Fish Commission. The former comprised four species of the genus *Catostomus*, or suckers, six of *Cyprinidae*, or chubs and dace, four of *Salmonidae*, the *Lota maculosa*, or ling, and the blob. The *Salmonidae* were as follows: *Coregonus williamsoni*, or whitefish, taken in both the Columbia and Missouri River basin; *Thymallus signifer*, or grayling, in the Missouri basin; *Salmo mykiss*, or Rocky Mountain trout, very abundant on both sides of the Divide; and *Salvelinus malma*, or Dolly Varden trout, in the upper waters of the Columbia River, in Montana. Specimens of the last-mentioned species have been said to attain a weight of 12 to 14 pounds.

During the years 1889 and 1890 seven species of *Salmonidae* were planted by the Fish Commission in eight different rivers and lakes of the Yellowstone National Park, each of which constituted a more or less isolated minor basin, as described in previous reports. Only two or possibly three of these basins had previously contained fish of any kind, and the new-comers were so distributed that only one or two

species were placed in each basin. An examination of these waters by Prof. Evermann showed conclusively that at least five of the introduced forms were doing well, two, if not more, having spawned; the white-fish (*Coregonus williamsoni*), however, had not survived the change, but as to the seventh species there was no reason to doubt that it was still living in its new home, although no specimens were observed. There are several falls in the park which are of such a nature that they could readily be provided with fishways; and Prof. Evermann suggests that this matter will merit consideration when the species planted by the Fish Commission have had sufficient time to become thoroughly established. By this means several native species which occur abundantly in some of the lower courses would be given the opportunity to disseminate themselves throughout the upper waters.

Great care was exercised in making the examinations relative to the selection of a suitable site for a hatching station, in order to be advised in case Congress should direct its establishment. Three places were found to present better advantages for this purpose than any others, and they are fully described in Prof. Evermann's report. They are Horsethief Springs, in Gallatin County; Botteler Springs, 3 miles south Fridley; and Davies Springs, 4 miles from Bozeman, all in Montana. In transmitting this information to Congress the Commissioner recommended the establishment of a trout-breeding station at one of the above-named localities, and the same has received favorable consideration. Davies Spring was subsequently selected for the purpose, as offering, in all respects, the best facilities.

The inquiries by Prof. Forbes, previously referred to, were begun on August 10 and were completed on September 13, 1891. They related to the lower classes of organisms which constitute the food of many fishes at different periods in their life-history, and to the physical characteristics of the waters examined. Owing to the difficulty in the way of making comprehensive collections of these smaller and more widely disseminated forms and of observing the conditions of their surroundings rendering progress much slower than with the fishes, the investigations were necessarily confined to fewer localities than had been visited by Prof. Evermann, but the region of the Yellowstone National Park had already been covered by Prof. Forbes's expedition of the previous summer, described in the last annual report.

The work of 1891 was mostly limited to the Flathead region of western Montana, with visits to Davies Springs, on Bridger Creek near Bozeman, and to Botteler Springs near Fridley, two sites suggested for the proposed new hatching station. The waters examined in the Flathead system were Flathead and Swan lakes, Flathead, Swan, and Cœur d'Alene rivers, and the Jocko River at Ravalli. A preliminary paper by Prof. Forbes* gives the general results accomplished during

*A preliminary report on the aquatic invertebrate fauna of the Yellowstone National Park, Wyoming, and of the Flathead region of Montana. By S. A. Forbes, Bull. U. S. Fish Comm., vol. xi, for 1891, pp. 207-258, plates 37-42.

both years, and contains descriptions of the principal features, physical and biological, of each of the basins studied by him, namely, the Snake River system, Yellowstone River system, Gardiner River system, Madison River system, and Flathead River system. Many of the organisms obtained are also described in detail.

As no topographical surveys have been made about Flathead Lake, its outlines and dimensions are still matters of conjecture, but it is said to be about 24 miles long and from 12 to 17 miles wide. Its principal characteristics, as compared with those of Yellowstone Lake, are thus described by Prof. Forbes:

Although this lake stands in some respects in decided contrast to Yellowstone Lake, these differences tend largely to neutralize each other. Flathead Lake is over 200 miles farther northward than Yellowstone, but the latter is 4,775 feet the higher above the level of the sea. These lakes lie on opposite continental slopes, their waters passing respectively into the Gulf of Mexico and the Pacific Ocean, but neither is more than a few miles from the relatively low continental divide, easily passable by most of the plant and animal forms likely to occur in such waters. Both lakes lie in the course of streams of considerable size, but these streams flow in opposite directions, the inlet of Flathead Lake coming southward from the British possessions, and its outlet running first to the south and then to the west as Flathead River, a branch of the Columbia, while Yellowstone River, rising about 150 miles from the lake, runs northward more than a degree below it before swinging to the east to join the Missouri. Nevertheless, the headwaters of the two river systems interlace almost inextricably through interlocking mountain valleys along several hundred miles of the main Rocky Mountain range. Both lakes lie among the mountains, from whose rugged gulches the snow never wholly disappears, and both are bordered by forest broken by park-like openings on the lower slopes; but the geological structure of the surrounding country and the chemical composition of the rocks which form their shores and beds differ widely for the two, and the forests, all pine and fir and other conifers around Yellowstone Lake, are largely deciduous trees about Flathead.

The lakes are similar in size and are both deep enough to give a deep-water character to their interior fauna, but Flathead has much the more uniform shore line and contains—if I may judge from the parts of it which we examined—a larger extent of shallow and weedy water. It is divided, in fact, by a chain of islands stretching across its lower third, into unlike parts, the northern deep and clear, and the southern shallow and easily stirred up to its clayey bottom by the winds. * * * The principal tributaries are the Flathead, a still, broad river, larger than the Yellowstone at the lake, running from Demersville, most of the way between flat, low banks; the Big Fork or Swan River, a rocky stream, whose course from Swan Lake to the Flathead is an oft-repeated alternation of wild rapids and comparatively quiet reaches; and Dayton Creek on the west, which I did not see. The outlet (Flathead River) flows rapidly away from the lake between bluffy banks which presently become a canyon.

TEXAS.

The act of Congress relative to investigations in the Rocky Mountain region also provided for similar inquiries with respect to the Gulf States. As the appropriation made for this purpose did not permit of extensive explorations, they were limited to the State of Texas, where it was expected a convenient location would be found to meet the requirements of a wide territory which has hitherto derived comparatively few benefits from the fish-cultural operations of the Government. The field work was conducted during November and the early part of

December, 1891, by Prof. B. W. Evermann, assisted by Dr. R. R. Gurley, of the Fish Commission; Dr. J. T. Scovell, of Terre Haute, Ind., and Mr. J. A. Singley, of the Texas State Geological Survey. The report of the investigation was transmitted to Congress with that bearing upon the Rocky Mountain region, and the two have been published conjointly.*

While it was of primary importance that the work of propagation in the Gulf region should relate to fresh-water fishes and to pond culture especially, it was considered desirable that provision should also be made for the hatching of marine forms and for experimental studies regarding oyster-culture, providing a suitable location on the seacoast could be found for the building of a composite station. Failing in this, attention was to be turned to the interior of the State, where good facilities for the first-mentioned purpose were known to exist, and the natural history of the different streams was also to be studied, so far as the time would permit.

Examinations were first made in the neighborhood of Galveston and about the bay of the same name, where some time was spent in ascertaining the relations between the salt and fresh waters, and in inspecting all localities which might present any advantages for the combined work. The results, however, were unsatisfactory, as nowhere could a reliable supply of fresh water be obtained without the construction of several artesian wells, and in close proximity to any suitable tract of land the salt water was of too low and variable a density to serve the purposes for which it was desired. A visit made subsequently to Corpus Christi Bay also failed to disclose the required conditions with regard to the fresh-water supply, and as no other places along the coast promised more favorable facilities, it was deemed advisable to abandon the scheme of uniting both stations in one locality.

The cretaceous limestone belt running through the State, near San Antonio, New Braunfels, San Marcos, and Austin, affords numerous very large springs, of which one or more are situated in the immediate vicinity of each of the places mentioned. All of these localities were visited and the conditions at each were found to be so satisfactory that further inquiries were considered unnecessary. The temperature of the water issuing from these several springs seems to be about the same, and does not vary much from 75° F. throughout the year. One group located just outside of the city of San Antonio, and called the San Antonio Springs, gives origin to the river of the same name; it is estimated to have an average flow of not less than 90,000 gallons per minute. Another group, the San Pedro Springs, is within the city limits, and has about half the capacity of the former. Comal Springs, the largest of which is said to supply as much as 50,000 gallons of water a minute, constitute the principal group near New Braunfels.

*A report upon investigations made in Texas in 1891. By Barton W. Evermann, PH. D. Published in conjunction with the report on western Montana and north-western Wyoming, as cited on p. CXI. Pp. 59-88, Pls. XXVIII-XXXVI. Contains also a supplementary paper, entitled "List of Crustacea collected," by Mary J. Rathbun.

The San Marcos River rises in a number of springs at the foot of a limestone ledge or hill just above the town of the same name. These springs together form a large, deep stream, from the bottom of which, near the upper end, wells up the principal spring with such force and in such quantity as to keep the surface of the river visibly convex above it. Some distance down a dam has been built, and just below the dam, at the edge of the town, is a tract of land about 25 acres in extent, well situated for the purposes of a fish-cultural station, and this will probably furnish the best advantages of any of the sites examined. Just above the city of Austin, Barton Spring helps to form Barton Creek, a good-sized stream, which empties into the Colorado River, and on the banks of which the State had formerly a hatching station. The land here is still suitable for the same purpose, but its extent may be too small.

Prof. Evermann's report contains a full account of the features observed at each of the places examined, together with brief notes on the fishes and crustaceans collected, the preparation of a more complete review of the aquatic fauna of the State having been necessarily deferred until a later time.

KENTUCKY AND TENNESSEE.

The southern tributaries of the Cumberland River between Nashville, Tenn., and the crossing of the Cincinnati Southern Railroad in Whitely County, Ky., a distance of over 150 miles following the main curvatures of the river, were examined during August and September, 1891, by Mr. Philip H. Kirsch, superintendent of schools of Columbia City, Ind. Fishes were collected in 20 different streams, including the following affluents of the Cumberland, together with some of their tributaries, namely: Stone River, Spring Creek, Round Lick, Carey Fork River, Roaring River, Obeys River, Beaver Creek, and the Big South Fork of the Cumberland. In Mr. Kirsch's report* the principal characteristics of the several streams are briefly described, and the fishes of each are enumerated in the form of annotated lists. The largest number of species recorded from any one stream was 39 from the Obeys River. An account of previous investigations in Kentucky by Mr. Kirsch and Mr. A. J. Woolman will be found in the last annual report.

INDIANA.

Mr. Philip H. Kirsch began, on June 13, 1892, an investigation of the fishes of the Eel River basin in Indiana, which was continued into the next fiscal year. This river, with its tributaries, lies between the main branch of the Wabash River and the Tippecanoe River, and extends

* Notes on a collection of fishes from the southern tributaries of the Cumberland River in Kentucky and Tennessee. By Philip H. Kirsch. Bull. U. S. Fish Com., **xi**, for 1891, pp. 259-268.

CXVIII REPORT OF COMMISSIONER OF FISH AND FISHERIES.

from the St. Joseph River basin in the northeastern part of the State to Logansport, where it empties into the Wabash River. It has a total length of 72 miles, the average width of its basin being about 18 miles.

OHIO.

During the summer of 1891, and again in May and June, 1892, Mr. Lewis M. McCormick, assistant in the museum of Oberlin College, acting in the joint interests of that institution and the Fish Commission, made extensive collections of fishes throughout Lorain County, Ohio, in continuation of investigations which had been carried on during the previous three years. In a report upon this work, which has been published by Oberlin College,* 88 species are enumerated as inhabiting the streams and the lake front of that county. Notes are also given respecting their habits and other matters of interest. A complete series of the species collected has been supplied to the Fish Commission. The following account of the main hydrographic features of Lorain County is abstracted from Mr. McCormick's report:

Lorain County is wholly within the lake watershed, all its streams flowing northward into Lake Erie. The streams are all small, the largest being Black River, navigable for about 3 miles, and Vermillion River, having only about a mile of safe water. * * * The land is quite flat, with a gentle slope toward the lake, and the streams are mostly shallow and sluggish, the exceptions being found in the parts that cross the "ridges," or old lake beaches, and a few of the small streams that are tributary to the Vermillion. Some of these are quite brisk and have worn for themselves deep channels in the shale. * * * Lake Erie, where it touches Lorain County, is shallow, reaching a depth of about 55 feet 3 miles from shore, and is free from islands. * * * Pound nets are set in "strings" from perhaps one-half a mile from shore to 3 miles, and it is from these I have obtained most of my lake fishes.

NORTH CAROLINA.

In April, 1892, Dr. Hugh M. Smith, of the Division of Fisheries, made a short trip to the Albemarle region of North Carolina, during which he collected fishes at numerous places in the basins of the Pasquotank and Roanoke rivers and in Edenton Bay, at the mouth of the Chowan River. Owing to the early date at which this investigation was conducted, high, muddy water was generally met with, and the temperature was also still low, causing unfavorable conditions for fieldwork, and making it impossible to obtain nearly as full a representation of the fishes of the region as would have been the case later in the season. Notwithstanding this fact, however, 45 species, belonging to 35 genera and 18 families, were secured. In a paper discussing the results of his expedition, † Dr. Smith describes the features existing

* Descriptive List of the Fishes of Lorain County, Ohio. By Lewis M. McCormick, assistant in the laboratory. Laboratory Bulletin No. 2, Oberlin College, Oberlin, Ohio, 1892, pp. 34. One map of Oberlin County, 14 plates of fishes.

† Report on a collection of fishes from the Albemarle region of North Carolina. By Hugh M. Smith, M. D. Bull. U. S. Fish Comm., vol. XI, for 1891, pp. 185-200.

about each of his collecting stations, and presents a very interesting series of observations relative to the different fishes taken at each place. Speaking of the region in general he states:

Albemarle Sound is said to be the largest coastal body of fresh water in the world, and it is certainly the largest of its kind in the *United States*. It is 60 miles long from east to west, and has a maximum width of 15 miles and an average width of 6 to 8 miles; its area is 453 square miles. At its eastern extremity it communicates on the north with Currituck Sound, and on the south it merges into Roanoke and Croatan sounds, through which it enters the ocean by means of openings in the sandy "banks" which skirt the ocean front of the State. * * * Viewed from the standpoint of commercial fishing, the Albemarle Sound region is one of the most important in the *United States*, and there is no other fresh-water basin on the Atlantic coast having such extensive fisheries. The especially prominent fish occurring here are the shad, alewives, striped bass, black bass, and white perch. The seine fisheries for shad and alewives are by far the largest in the country.

During the summer of 1888 the upper waters of the main tributaries of Albemarle Sound were made the subject of an extensive inquiry by Dr. David S. Jordan, but the fishes in the lower part of the basin had never been studied previous to the visit of Dr. Smith.

NEW YORK.

It is appropriate to notice in this connection an important investigation respecting the fishes of Lake Ontario, conducted during August and September, 1891, by Dr. Hugh M. Smith, in view of the fact that the report upon it deals mainly with *natural-history* subjects.* In describing the results of his expedition, the author has incorporated much material from other sources, and his notes upon the important commercial fishes of the lake contain, in addition to his own observations, an epitome of the principal facts previously made known regarding them. The species treated of are the sturgeon, alewife, shad, Atlantic salmon, lake trout, the common and lesser whitefishes, the pike perches, strawberry bass, and many so-called bait fishes. Special attention is given to a discussion of the sources of introduction into the lake of the alewife, and the possible causes of the great and strange mortality which destroys enormous quantities of them every year; to the history of the Atlantic salmon, once not an uncommon inhabitant of the lake, but now almost entirely exterminated from it; and to the whitefishes, concerning which, aside from the common form, an uncertainty still exists as to the number of species represented and the proper identity of some of them.

* Report on the Fisheries of Lake Ontario. By Hugh M. Smith, M. D. Bull. U. S. Fish Comm., vol. x, for 1890, pp. 177-215, plates XXI-L.

WISCONSIN.

A physical and biological investigation of Green Lake, Wis., was conducted by Prof. C. Dwight Marsh, of Ripon College, during August, September, and October, 1890, and July, 1891. As assistance was rendered to Prof. Marsh by the Fish Commission to the extent of supplying him with the means of taking deep-water temperatures, we feel justified in referring to some of the results of his inquiries, which have been described in two papers.* They derive additional interest, moreover, from the fact that other lakes in the same state—Geneva and Mendota—have been made the subject of special studies for this Commission by Prof. S. A. Forbes.

The maximum depth recorded for Green Lake, which is situated southeast of the center of the State, is 195 feet. Temperature observations were secured by Prof. Marsh down to a depth of 58 meters. A minimum temperature of 5.28° C. was obtained in the deeper parts of the lake, in July, 1891; in August, 1890, the temperature in corresponding depths was 6.6° C. The author infers that the maximum bottom temperature is reached in August, and remains practically the same during the two following months. The surface temperature is nearly uniform over all the deeper parts of the lake. Prof. Marsh states:

Because of its depth, Green Lake resembles in the conditions controlling animal life, the larger bodies of water, and might be expected to have a fauna somewhat different from that of the shallower lakes. My collections seem to justify this expectation.

The mollusks obtained were all littoral forms, and in most cases were probably washed in from shallower water. Crustaceans are abundant, although the number of species is small, only 16, including both the pelagic and abyssal forms, having been discovered. "When we compare the deep-water crustacea of Green Lake with those of Lake Michigan and Lake Superior, as shown in the lists published by Prof. Smith and Prof. Forbes, we find a striking similarity. That this should be true of the pelagic fauna is not strange," but the presence of the same abyssal forms which never come to the surface is not so easily explained, as there seems to be no geological evidence of any connection between Green Lake and either the Mississippi Basin or the Great Lakes, by which these deep-water animals could have migrated to their present location.

MEXICO.

Reference may here be made to an expedition into Mexico during the summer of 1891, on which Mr. A. J. Woolman acted as ichthyologist, as his report upon the fishes was accepted for publication by the Fish Commission.† The party traversed the northern and central parts of

*On the deep-water crustacea of Green Lake. By C. Dwight Marsh. Trans. Wisconsin Academy of Sciences, Arts, and Letters, vol. viii, pp. 211-213.

Notes on depth and temperature of Green Lake. *Idem*, pp. 215-218, 1 plate.

† Report on a collection of fishes from the rivers of central and northern Mexico. By Albert J. Woolman. Bull. U.S. Fish Comm., xiv, for 1894, pp. 55-66, plate 2.

Mexico on its way south to Mount Orizaba, which was the objective point. According to Mr. Woolman:

In mountainous regions the number of species of fishes is small, and this is especially true in Mexico, where the streams are short, their basins isolated, and their volume of water varies greatly from one season to another.

The total number of species obtained was only 24, of which 6 were new to science, and as the entire collection was made in the head waters of the streams, all of the forms belong strictly to fresh water. Of the species collected south of the Rio Grande, 50 per cent belonged to the *Cyprinidae* and 30 per cent to the *Cyprinodontidae*, the remaining 20 per cent representing five other families. The streams visited are as follows: The Rio Grande at El Paso del Norte; Rio de los Conchas at Chihuahua; Rio de Lerma at Salamanca; the lakes and canals about the City of Mexico, and the Rio Blanco at Orizaba. Some of the collections were made at altitudes of 4,000 to 6,000 feet above the level of the sea.

MISCELLANEOUS INQUIRIES.

FRENCH METHODS OF OYSTER-CULTURE.

The marked depletion of oyster-grounds which has taken place on some parts of the Atlantic seacoast of the United States, the difficulty generally encountered in procuring an adequate supply of seed for planting purposes, and the very commendable efforts made or contemplated with respect to the establishment of new oyster-producing areas on both sides of the American continent, have all been fruitful sources of inquiry, calling for information of a thoroughly practical kind. To assist in meeting this demand the U. S. Fish Commission has not only carried on many investigations and experiments relative to the oyster question, but it has also sought to disseminate the experiences acquired in other countries by printing, from time to time, accounts of the methods employed by foreign culturists.

The relative scarcity of oysters in Europe as compared with this country and the high prices there received for them has led to a system of cultivation which at present would be neither expedient nor profitable on our own coasts, and it is sincerely to be hoped that the time is still far distant when this mollusk shall become a luxury to the American people. But, however that may be, much benefit can undoubtedly be derived from a study of the different systems resorted to in Europe, some features of which may prove applicable to our own needs or be at least suggestive. The French Exposition of 1878 was made the occasion for bringing together the literature relative to the history and conditions of oyster-culture in the several European countries where it was then practiced or where experiments had been undertaken regarding it. A comprehensive review of the subject, based upon inquiries made at the same time, was also promised but never completed, and translations only of some of the principal papers were published in the Fish Commission annual report for 1880.

Another opportunity to secure these observations was fortunately presented about a year ago, when Dr. Bashford Dean, of Columbia College, New York, started upon a trip to Europe, intending to be absent for some time. Arrangements were accordingly made with him to visit all of the oyster-producing countries of the old world and to report fully upon the methods there employed, paying especial attention to those matters which might prove of most interest to American oyster-growers. Dr. Dean was well qualified to conduct this investigation, having been connected during several years with the oyster commission of New York State, and having served as naturalist and physicist of the steamer *Fish Hawk* on the oyster survey of South Carolina in 1890-91. During the past fiscal year he completed his studies in France, Spain, and Portugal, and his report relative to the first-mentioned country has been received and published.* It presents a thoroughly comprehensive but concise account of the industry as now carried on; and the illustrations which accompany it, mostly engraved from photographs by the author, emphasize the more essential features of that remarkable system of artificial culture by which the French have maintained their high standard of production.

After explaining the differences existing between the flat, northern, or genuine French oyster and the introduced Portuguese species, and discussing briefly the Government regulations with regard to dredging on the natural beds, the author takes up the different branches of oyster-culture under the following headings: Production, or the raising of seed oysters, and kinds of collectors; cleavage, or the growing of oysters for market; claires; special processes, such as "greening" or preparing for transportation. The following remarks are taken in part from the introduction and in part from the concluding chapter of this paper:

When one has carefully examined oyster-culture in France it appears more than ever manifest why the industry at home has been a profitable one. It has certainly required the exercise of but little labor, and all costly methods of cultivation could have proven of little practical value. So great has been our natural supply of oysters that we have always thought far distant the need of replenishment.

If, however, the present condition of our industry must be improved, there are fortunately but few natural obstacles to overcome, and we may well be hopeful. Our oysters are of a hardy and prolific species, our coast is a natural collecting-place for seed, and the conditions of our oyster-bearing grounds are practically as good as ever. We have in no degree the adverse conditions that the French have so successfully encountered. Their coast regions, in the first place, favorable to a natural growth of oysters, are both few and small. Their waters, even in some of the best-known localities, are often turbid, accumulate sediment, and give rise to shiftings of muddy bottoms. Culture has had to bring into use the softest flats and mud banks, crusting them over with gravel and sand; it has had to devise every possible way of protecting its oysters from sediment, mud burial, and enemies. Finally, there are but two points along their entire coast where seed oysters occur in any natural abundance. Skill in culture, however, has enabled Arcachon and Auray to supply readily the great home demand for seed, and even to furnish in large part the parks of the Low Countries and England, a success the more remarkable when

* Report on the Present Methods of Oyster-Culture in France. By Bashford Dean. Bull. U. S. Fish Com., x, for 1890, pp. 363-388, plates 68-78.

we consider how recently was the French coast so depleted that for the first experiments in cultivation the oysters were actually purchased from other countries.

Natural difficulties have caused the French to study division of labor in the industry; to make, for example, one locality furnish the seed, another to raise the oyster to maturity, a third to flavor or color it, and sometimes even a fourth to prepare it for transportation.

Under these conditions the growth of the industry has been especially and almost entirely dependent upon the wise action of the Government. The reservation of the natural grounds as state property and the forbidding of general public dredging is generally regarded as the keystone of French oyster-culture. These grounds, once exhausted, now flourishing, are regarded as the permanent capital of surrounding areas, whose profits in the form of seed oysters are shared by all alike.

In view of our present needs, what is the most important lesson we are to draw from the studies of the French oyster-culture? The most practical, certainly, seems the action of the Government in reserving oyster-bearing tracts for the purpose of furnishing seed. This prudent restriction has been the safeguard of the entire French industry. Our oyster-grounds are becoming exhausted solely by the enormous drain upon their resources. In general their conditions for culture are as rich as ever. The oysterman has sent to market practically all of his oysters and expects the beds on his neighbor's ground to furnish him with seed. Too often, however, the neighbor has been equally thrifty and has marketed all of his product. The following year both are astonished at the pooriness of the set, attributing it to coldness and rain, but they never think that the deficiency might have been caused by the want of a quantity of neighboring oysters sufficient to furnish the spat. Nor is one to blame for not preserving his oysters to furnish seed for everybody. French political economy has assigned to Government the duty of reserving oyster-bearing tracts for the common good, and the Government has studied where these might most judiciously be located so as to profit all alike. The tracts need not be large and would not be of great expense to the state, at any rate as an experiment in a single locality. The grounds would practically take care of themselves; their only expense would be that of a guardian.

If an experimental oyster tract in one locality should prove eminently successful to neighboring seed-culture, a more general legislative action in different States might reasonably follow. The matter would certainly be most heartily seconded by the oystermen themselves. We should not expect seed to be abundant where oysters are lacking. And our industry may, for many years to come, demand nothing more pertinent to its welfare than State spawning-grounds near centers of oyster-culture.

With regard to the production of seed oysters in the United States on some such principle as has been followed by the French, the main question is whether it would pay, in view of the higher price of labor in this country. While not expressing a positive opinion in the matter, Dr. Dean is not inclined to answer the question in the negative, and in respect to this subject he presents many facts which are deserving of careful consideration.

THE SPANISH MACKEREL, *SCOMBEROMORUS MACULATUS*.

The experiments relative to the hatching of this species, together with the study of its life-history and habits, begun on June 14, 1891, were continued until July 31. The results obtained during the former month have been referred to in the last annual report. The work was conducted in the neighborhood of Cape Charles City, Va., on board the steamer *Fish Hawk*, Lieut. Robert Platt, U. S. Navy, commanding, the

biological investigations being carried on by Mr. J. Percy Moore, of the University of Pennsylvania.

The earliest catch of Spanish mackerel at Cape Charles City was reported on May 26, but stormy weather interfering with fishing operations and keeping the water at a relatively low temperature, only small numbers were obtained in the beginning, and, in fact, they were not at all abundant at any time during the season. The first ripe fish were not taken until June 17, but from that date up to July 31 from 1 to 8 mature females were secured on each of twenty-five days, the total number of fish from which eggs and milt were obtained amounting to 97 females and 121 males. From 1,000 to 330,000 eggs were fertilized each day, or a total of 2,494,000 eggs for the season, and an average of 25,711 eggs to each female. Several entire lots of spawn, amounting to 516,000 eggs, died before hatching. From the balance 829,000 embryos were secured, making the proportion of eggs hatched 41.9 per cent. There was considerable variation among the different lots in this respect, however, some yielding only 4 per cent of fry and others as high as 63 per cent; the proportion was seldom less than 25 per cent, and generally above 30 per cent. The period of incubation up to the time when hatching began ranged from 21 to 29½ hours, and for all the lots averaged 24¾ hours. The rate of development of the embryos was found to be greatly affected by temperature and amount of sunshine, and electrical conditions seemed also to have their influence, but to what extent could not be ascertained.

Temperature and density observations were kept up during the progress of the work, but as corresponding observations for the period just preceding the appearance of the ripe fish are lacking it is not possible to determine what relations the spawning functions bear to changes in the physical condition of the water. The surface-water temperature was subject to considerable and often sudden variation, corresponding to fluctuations in the air temperature, dependent upon the time of day, conditions of weather, etc. Four observations were made daily, namely, at 6 a. m., noon, 6 p. m., and midnight. On June 18 the water temperature at these hours was 77.5°, 80°, 78°, and 78°, respectively. The record for the entire season shows that the temperature at 6 a. m. ranged from 72° to 80°; at noon, from 72° to 82°; at 6 p. m., from 73° to 84°; and at midnight, from 74° to 81°. The densities, corrected to 60° F., ranged from 1.0134 to 1.0186, being, of course, greatly influenced by the tides.

The fish made use of in connection with these experiments were obtained from the different traps distributed between Hungers Wharf and Butlers Hole, the catch from which is mostly marketed at Cape Charles City. Spawn-takers were on hand whenever the traps were hauled, and it is gratifying to acknowledge the hearty coöperation which they received from the fishermen. Mr. Moore always accompanied one of the parties, and was thus enabled to greatly extend the scope of his observations. The following notes are based mainly upon a preliminary report which he has furnished:

The Spanish mackerel were never abundant, and in the beginning the prospects seemed very discouraging, but about June 24 somewhat better runs began. The small amount of spawn taken, however, was not due entirely to the scarcity of fish. The difficulty arose mainly from the fact that the fish appear to spawn chiefly at night or in the early evening, and when the traps were hauled in the morning the ova sacs were generally empty. The great pressure produced by the lifting of the nets and the violent struggles of the fish when they are closely massed together may also be held partly accountable for this result. The experience gained this season in the collecting of the fish leads to the conclusion that the pounds as run for commercial purposes can not be relied upon to furnish a large supply of spawn, and the use of gill nets proved an entire failure, as described in the last report. In the event of extensive operations in the hatching of this species it would, therefore, be greatly to the advantage of the work if one or more pounds could be controlled entirely in this interest, in order that they might be tended and the fish removed at the proper times to insure the retention of the spawn and milt. Such an arrangement could readily be made. The most satisfactory fishing-ground was found at the mouth of Hungers Creek, where there are also excellent facilities for the establishment of an inexpensive hatching station.

The spawn of the Spanish mackerel does not all mature at the same time, and each of the full ovaries examined contained eggs in all stages from the ripe condition down to the minute, nucleated, cell-like eggs of incipient development. Each fish, even under the best conditions, yielded only a comparatively small amount of mature eggs, the greatest number taken from a single individual having been 60,000, and this was far in excess of the usual experience. It is impossible to reconcile this result with the figures given in connection with earlier experiments respecting the Spanish mackerel, made in the same locality, when over a million mature eggs were sometimes credited to a single fish, but this much can be said, that the observations made in 1892 were conducted with great care, and it is considered that they may be entirely relied upon. It is also noticed by Mr. Moore that the two sexes seemed to school more or less separately, and of the specimens secured the males greatly exceeded the females in numbers.

The experiments appeared to indicate that it is immaterial whether a constant current of water is maintained in the hatching apparatus or not, so long as the jars are kept scrupulously clean and are not overcrowded. The good eggs are all hatched before they can be affected by the decomposition of a few dead ones, when the fry can be removed to a place of safety. The jars should be made of glass or at least have enameled surfaces to prevent the rupture of the egg membranes, which are especially delicate in this species. The tidal cod jars were employed with best success on the *Fish Hawk*, not more than 60,000 eggs generally being placed in each. One small lot of eggs treated in a jar of this character, with quiet water, hatched to the extent of 90 per cent.

For the reasons above explained the greatest care must be exercised in taking and handling the spawn. It would be preferable to use filtered water in the hatching work, in order to escape the accumulation of sediment, which settles at the bottom of the jars, and, together with dead organic matter, tends to kill the eggs in water of low density. This probably may be obviated, however, by maintaining a higher density than sometimes occurs in this locality, by which means the eggs are kept floating and out of danger. The best results were accomplished and, in fact, nearly all the hatching was done under the latter conditions, which also insure a ready way of separating the good from the bad eggs, sufficiently accurate for all practical purposes.

In any future experiments it will be advisable to determine if some economical means can not be devised for holding the fry in confinement until they reach a size when they are better able to take care of themselves. This question has been satisfactorily settled with respect to several other species, and the success which may be attained in the propagation of Spanish mackerel will be measured by the extent to which this feature can be carried out. When the fry are deposited in the open waters of Chesapeake Bay their existence is at once threatened by the strong currents and often heavy sediment, and in all places, however much sheltered, they are the prey of multitudes of young fishes which swarm in this region. Even though the utmost care was exercised, however, it was found impossible to keep the fry in an aquarium on board the *Fish Hawk* for more than one week, but in a properly constructed tidal inclosure better success might possibly be obtained. After the fry began feeding in the aquarium their stomachs were observed to contain a few minute green algae and a mass of material evidently derived through the disintegration of organic substances. The food of the adults during June and July consisted chiefly of young alewives, which were very abundant about the ship, together with various cyprinodonts, silversides, etc. They doubtless devour any small fishes that come in their way.

Some progress was made in the study of morphology and embryology of this species on board the *Fish Hawk*, and material was preserved for the purpose of continuing these researches at a later time.

RIVER POLLUTION.

In February, 1892, the Fish Commission was requested to investigate what was claimed to be a serious case of pollution in the Susquehanna River near the town of Havre de Grace, Md., having its source in a large mill where paper is manufactured from wood pulp. An examination of the conditions existing near the mill was made at once by Prof. Evermann, and careful tests were applied to determine the possible effects produced by the outflow of the waste liquor. The results of the inquiry were not conclusive, and, in fact, the studies have not been entirely completed, but, in view of the widespread

interest which attaches to any information bearing upon this much-disputed subject, it seems important to present a brief review of the investigation so far as it has been carried on.

At the mill in question five large digesters are used for converting the wood into pulp, and in each of these from 1,000 to 1,200 gallons of sulphurous acid, or a total of 5,000 to 6,000 gallons, are employed daily. The contents of the digesters are subjected to steam heat for a period of twenty-four hours, after which the acid passes through a trough into the river at a point where a strong current issues from several turbine wheels. The direction of this current is such that it tends to retain the acid for some time along the right shore of the river—that on which the mill is located. The volume of water said to pass the turbine wheels amounts to about 1,000,000 gallons per minute, which is estimated to be not far from one-fifth the average flow of the river at this place. Five minutes are consumed in emptying each digester, during which time 5,000,000 gallons of water would issue at the same point, and in that case the mixture of acid with water would be in the proportion of 1 part of the former to 5,000 parts of the latter; but should all the digesters be emptied at the same time the proportion would change to 1 part of acid to 833 parts of water. This latter occurrence is not probable, however, and, in any event, according to the statement of the manager of the mill, the entire outflow of acid during any twenty-four hours would not exceed their total capacity of 6,000 gallons.

On the part of the fishermen it was claimed that whenever schools of fishes approached the locality occupied by the mill they were driven back and disappeared, and, in fact, that they have come to avoid the neighborhood, greatly to the detriment of the fishing interests. Unfortunately, at the time the examinations were made the season was still too early to observe the direct effects of the polluted water, and although it was arranged that the Commission should be informed as soon as the fish began running no notice to that effect has been received. Samples of the acid, of the waste liquor as it issues from the mill, and of the river water at the time of emptying a digester, at distances of 100 and 400 yards and of $1\frac{1}{2}$ miles below the outlet, were obtained, however, and sent to Washington. None of the samples of river water showed by color or smell any perceptible trace of acid contamination. The waste liquor as it passes out from the digester is a dark-reddish liquor, having a specific gravity of 1.006 at 4° C. and a pungent odor, apparently of sulphurous acid and creosote. The following experiments with this refuse product mixed with water were made by Dr. R. R. Gurley:

A shiner, roach, and young sunfish were placed in such a mixture, beginning with the proportion of 1 part of acid to 250 parts of water and gradually increasing the strength to 4 per cent of acid, during a period of four days, but with no deleterious effect upon the fishes. The odor and taste of the acid first became perceptible when the proportion of the same reached 1.2 per cent. A young sunfish remained alive and apparently without suffering during twenty-four hours in a mix-

ture containing 10 per cent of the waste liquor. A young shad was placed in a solution of 1 per cent strength of acid, which was increased by 1 per cent additions until 10 per cent was reached. The first definite results were obtained with strength of 7 to 8 per cent, and consisted in slight distress, especially in progressive enfeeblement of muscular action. At 10 per cent this was more marked, and after one to two hours the fish died from suffocation, as evidenced by paroxysmal efforts to escape and frequent choking gasps at the surface. One fish similarly immersed, but removed to pure sea water at the first moment that loss of equilibrium was observed, was easily revived. Young shad were subsequently put directly in strong solutions ranging from 10 to 33½ per cent of acid, which produced more sudden and acute effects.

Dr. Gurley concludes from his experiments that fish can support for a long period mixtures into which this refuse does not enter in a greater proportion than 10 per cent; that in greater strengths, even up to 25 per cent, the fish would often have time to make its escape before being overwhelmed; and that at about 33 per cent the point is reached where the fish is overwhelmed at once, and his escape would usually not be possible.

In summing up the results, Prof. Evermann remarks that—

While it does not seem evident from these tests that the fishes of the Lower Susquehanna could be affected as seriously as has been supposed, it should be borne in mind that while the contamination may not be great enough to kill fishes, it might be sufficient to drive them from that part of the river where the mill is located. They began using sulphurous acid at the mill about January 14, 1891. According to the fishermen, the herring fishing began a few days earlier than usual in the spring of 1891, and was fairly good until about April 30, when the fish suddenly disappeared, this being several days earlier than they generally leave. At the same time numerous such fish were seen upon the surface of the water at various places below the mill. Whether these results were due to contamination from the mill can not be certainly stated.

DISEASES AND PARASITES OF FISHES.

Dr. R. R. Gurley has continued his researches respecting the diseases of fishes, a subject which constitutes one of the most important lines of inquiry within the province of this division. While the successful determination of the causes of mortality and especially of epidemics among fishes in their wild state will be exceedingly interesting and possibly productive of much good, it is the fish-culturist who will appreciate most highly the solution of any one of the many perplexing problems of this nature which are associated with his work. The sudden appearance of some unknown disease or rapidly spreading parasite, for which no remedy has been discovered, affecting breeding stock, the eggs or embryos, or the young fishes held in temporary confinement, is a matter of frequent occurrence, and too often results in great destruction. Scarcely a year passes without receiving complaints of serious losses from some such cause, the origin and, in fact, the actual conditions of which have never been accounted for,

During the winter of 1891-92 much trouble was experienced with the eggs of many of the rainbow trout at the Neosho Station, Missouri, which, when extruded from the females, were hard and fully rounded, falling into the receiving pan like shot, and failing to become fertilized by contact with the milt. The same peculiarity had also been observed previously at other stations. Prof. C. E. Riley, of Drury College, Missouri, who examined the eggs while the stripping was still in progress, was inclined to attribute their abnormal condition to the presence of many minute organisms discovered in the fluid which issued with them from the ovarian openings. Dr. Gurley, however, who was prevented from visiting the station at that time, but who was furnished with a series of the eggs preserved in alcohol, discredits this view and has suggested two other possible causes, namely, prematurity on the part of the spawners, which were only twenty months old, and inflammation of the ovaries.

Mr. W. F. Page, superintendent of the Neosho Station, does not consider either of these explanations satisfactory, as rainbow trout from five to nine years old have furnished eggs of the same character in the past, and the fish in question had been stripped this year for the first time, so that inflammation could not have been produced in them from excessive handling.

The solution of this question must, therefore, be left until another opportunity occurs to study specimens affording the hard eggs during the spawning period.

Dr. Gurley has now in course of preparation a complete review of the extensive group of protozoan parasites termed Myxosporidia, which infest fishes and also some other kinds of aquatic animals, and are sometimes the cause of great mortality among them. No systematic revision of the group has yet been published, and the descriptions of the different forms are mainly scattered through the pages of various journals. Such American species as can be obtained will be discussed from a study of the fresh material.

COLLECTIONS, PREPARATION OF REPORTS, ETC.

The quarters assigned to this division for laboratory purposes in the Central Station of the Fish Commission at Washington are no longer adequate to meet the increased requirements of the work, and additional space is much needed. This want is mainly felt in respect to accommodations for special biological and physical inquiries, which are now so poorly provided for as to greatly retard their progress, while, at the same time, the demands for information based upon such studies are becoming more urgent every year. There is also insufficient storage space for the large collections constantly arriving from the several vessels and field parties, which are now performing practically continuous service during all seasons. Although it is not intended to retain from these collections more than a small type series, to serve for the identification of species, yet, owing to the slow progress necessarily

made in the elaboration of results by the few assistants now employed, it must be expected that large quantities of material will always remain on hand.

The extensive investigations conducted in the interior of the country have supplied the main part of the natural-history collections received during the past year, much less than usual having been derived from the inquiries of the *Albatross*, in consequence of the almost continuous detail of that vessel to special duties. The dredgings and fishing trials made in the Strait of Juan de Fuca, at the Hawaiian Islands while on the cable survey, and to some extent in Bering Sea and along the Aleutian Islands in connection with the fur-seal expeditions, contributed many things of interest, however, and on the visit paid to the Commander Islands several specimens were obtained of the fur seals belonging on the Asiatic coast.

The fresh-water fishes have been mostly studied by Prof. B. W. Evermann, who has the direct charge of that group. The general collection of marine fishes made by the steamer *Albatross* has been referred to Prof. Charles H. Gilbert, of Leland Stanford Junior University, who has been at work for some time on the earlier collections from the same source, while Prof. O. P. Jenkins, also of the Stanford University, will report upon the special and very interesting series secured at the Hawaiian Islands. The *Albatross* mollusks and higher crustaceans are being attended to at the U. S. National Museum, the former group by Mr. William H. Dall, curator of the department of mollusks, the latter by Mr. James E. Benedict and Miss M. J. Rathbun, of the department of marine invertebrates. To Mr. Benedict has also been assigned the collection of annelids made during the cruise of the steamer *Albatross* from Norfolk to San Francisco in 1887-88. The crayfishes obtained in connection with the interior investigations are being studied by Prof. Walter Faxon, of the Museum of Comparative Zoology.

During the summer of 1891, when Prof. Charles H. Gilbert finally severed his connection with the Indiana University, he returned to Washington all of the *Albatross* fishes on which he had completed his observations, comprising nearly all of the specimens collected in the North Pacific Ocean south of Alaska, and forming a very large collection. The remainder, chiefly from Bering Sea, were forwarded to him at the Stanford University.

The last annual report contains an account of an expedition by the steamer *Albatross* during the early part of the calendar year 1891 off the west coast of Mexico and Central America and to the Galapagos Islands, under the scientific direction of Mr. Alexander Agassiz, director of the Museum of Comparative Zoology of Harvard University, and reference is also made in the same connection to the valuable natural-history results obtained. As Mr. Agassiz offered to provide, at his own expense, for the study of this material and the publication of the reports upon it, the matter was placed entirely under his supervision and will be directed by him from Cambridge, Mass.

The collections were assorted partly in Washington and partly in Cambridge, and during the past year the different groups have been distributed for study among a number of specialists who were selected with reference to their previous acquaintance with the subjects assigned them, several having participated in the working up of the collections obtained during the famous cruise of H. M. S. *Challenger*. Their reports, when they shall have been completed and published, will undoubtedly constitute one of the most important series of contributions ever issued respecting the biology of the deep sea.

The assignments made have been as follows:

The birds, to Mr. Robert Ridgway, U. S. National Museum; reptiles, to Mr. Leonhard Stejneger, U. S. National Museum; fishes, to Mr. Samuel Garman, Museum of Comparative Zoology; phosphorescent organs of fishes, to Dr. R. von Lendenfeld, Innsbruck, Austria; cephalopods, to Prof. William E. Hoyle, Owens College, Manchester, England; gastropod, lamellibranch, and scaphopod mollusks, to Mr. William H. Dall, U. S. National Museum; nudibranch mollusks, to Dr. R. Bergh, Copenhagen, Denmark; pteropods and heteropods, to Dr. P. Schiemenz, Zoological Station, Naples, Italy; ascidians, to Prof. W. A. Herdman, Liverpool, England; salpidæ and doliolidæ, to M. P. A. Trautstedt, Denmark; bryozoans, to C. B. Davenport, Museum of Comparative Zoology; land insects, to Prof. C. V. Riley, Washington, D. C.; halobatidæ, a group of pelagic insects, to Mr. E. P. van Duzee, Buffalo, N. Y.; pycnogonids, to W. Schimkewitch, St. Petersburg, Russia; crustaceans, to Prof. Walter Faxon, Museum of Comparative Zoology; ostracods, to Dr. G. W. Müller, Greifswald, Germany; annelids, to Mr. James E. Benedict, U. S. National Museum; sipunculoid worms, to Mr. H. B. Ward, Troy, N. Y.; sagittæ, to Dr. K. Brandt, Kiel, Germany; planarians, to Mr. W. McM. Woodworth, Museum of Comparative Zoology; holothurians, to Prof. Herbert Ludwig, Bonn am Rhein, Prussia; echini, to Mr. Alexander Agassiz; starfishes, to Mr. W. Percy Sladen, London, England; ophiurans, to Prof. C. F. Lütken, Copenhagen, Denmark; comatulæ to Dr. C. Hartlaub, Göttingen, Germany; stalked crinoids, to Mr. Agassiz; antipathes, to Mr. George Brook, Edinburgh, Scotland; alcyonarians, to Prof. Theodor Studer, Berne, Switzerland; actinarians, to Prof. E. L. Mark, Museum of Comparative Zoology; actinian and hydroid corals, to Dr. G. von Koch, Darmstadt, Germany; hydroids, to Prof. S. F. Clarke and Mr. F. E. Peabody, Williams College, Mass.; aculephs and pelagic fauna generally, to Mr. Agassiz; siphonophores, to Mr. C. Chun, Breslau, Germany; sponges, to Prof. H. V. Wilson, University of North Carolina; foraminifera, to Prof. A. Goës, Stockholm, Sweden; thalassicolæ, to Dr. K. Brandt, Kiel, Germany; nullipores, to Prof. William Farlow, Harvard University; samples of ocean bottom, to Mr. John Murray, Edinburgh, Scotland; geological specimens, to Mr. George Merrill, U. S. National Museum. Mr. John Murray, who directed the preparation of the scientific results of H. M. S. *Challenger* after the death of Sir Wyville Thomson, has also been furnished with

a complete series of the bottom samples taken by the steamer *Albatross* during the recent investigations in the North Pacific Ocean and Bering Sea, on which he has promised to prepare a special report.

A very large amount of material in the line of fishes and marine invertebrates, derived mainly from the expeditions of the *Albatross* and the investigations in Montana and Wyoming, has been transferred to the custody of the U. S. National Museum, and also a large series of plants and many bird and mammal skins collected incidentally in Alaska. Sets of duplicate specimens of natural history selected from the collections made by the Fish Commission have been prepared and distributed by the National Museum to the following institutions: Biological School, Avon by the Sea, N. J.; Wells College, Aurora, N. Y.; Trinity University, Durham, N. C.; Fort Worth University, Fort Worth, Tex.; State Normal School, Mankato, Minn.; Iowa State Normal School, Cedar Falls, Iowa; State Normal School, Whitewater, Wis.; Mansfield Memorial Museum, Mansfield, Ohio; Leland Stanford Junior University, Cal.; Pennsylvania State Normal School, Millersville, Pa.; Tulane University, New Orleans, La.; National Deaf-Mute College, Washington, D. C.; The Australian Museum, Sydney, New South Wales; University of Toronto, Canada; Royal Zoological Museum, Copenhagen, Denmark.

In addition to the above, several requests from specialists for material of different kinds, desired for the study of biological problems, have been met directly by the Fish Commission.

Besides the papers referred to on preceding pages, the following, descriptive of Fish Commission materials, either wholly or in part, have been published during the past year:

Fishes collected by William P. Seal in Chesapeake Bay, at Cape Charles City, Va., September 16 to October 3, 1890. By Barton A. Bean. Proc. U. S. Nat. Mus., vol. xiv, pp. 83-94, 1891.

Preliminary descriptions of 37 new species of Hermit Crabs of the genus *Eupagurus* in the U. S. National Museum. By James E. Benedict. Proc. U. S. Nat. Mus., vol. xv, pp. 1-26, 1892.

The Genus *Panopeus*. By James E. Benedict and Mary J. Rathbun. Proc. U. S. Nat. Mus., vol. xiv, pp. 355-385, Pls. xix-xxiv, 1891.

Scientific results of explorations by the U. S. Fish Commission steamer *Albatross*. No. xx. On some new or interesting West American shells obtained from the dredgings of the U. S. Fish Commission steamer *Albatross* in 1888, and from other sources. By William H. Dall. Proc. U. S. Nat. Mus., vol. xiv, pp. 173-191, Pls. v-vii, 1891.

Scientific results of explorations by the U. S. Fish Commission steamer *Albatross*. No. xxi. Descriptions of Apodal fishes from the tropical Pacific. By Charles H. Gilbert. Proc. U. S. Nat. Mus., vol. xiv, pp. 347-352, 1891.

On a peculiar type of arenaceous foraminifera from the American tropical Pacific. *Neusina agassizi*. By A. Goës. Bull. Mus. Comp. Zool., vol. xxiii, No. 5, pp. 195-197, 1 plate.